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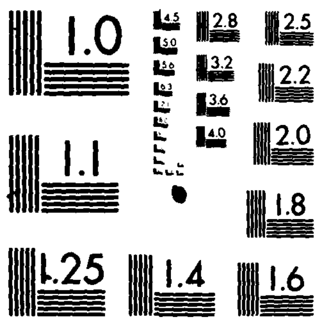

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US Army Corps
of Engineers
Engineer Institute for
Water Resources

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The Evaluation of Water Conservation For Municipal and Industrial Water Supply: Illustrative Examples

Water Conservation and Supply Information Transfer and Analysis Program

(Contract Report 81-C1, REVISED)
Contract Report 82-C1

February 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER IWR Contract Report 82-C1	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Evaluation of Water Conservation For Municipal and Industrial Water Supply - Illustrative Examples (Revised)		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Duane D. Baumann John J. Boland John H. Sims		8. CONTRACT OR GRANT NUMBER(s) DACW72-82-M-0160
9. PERFORMING ORGANIZATION NAME AND ADDRESS Planning & Management Consultants, Ltd. Post Office Box 927 Carbondale, Illinois 62901		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Water Resources Support Center U.S. Army Engr. Institute for Water Resources Fort Belvoir, Virginia 22060		12. REPORT DATE February 1981 13. NUMBER OF PAGES 356
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Conservation, water supply, planning.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report consists of accounts of illustrative applications of proposed planning procedures under two different sets of circumstances. These applications, based on data from Atlanta, Georgia and Tucson, Arizona metropolitan areas, include hypothetical as well as actual data, and do not represent complete applications in either locality. They show methods, approaches, techniques; they do not show results or conclusions.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

THE EVALUATION OF WATER CONSERVATION FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY (REVISED)

ILLUSTRATIVE EXAMPLES

A Report Submitted to the:

Institute For Water Resources
Water Resources Support Center
Kingman Building
Fort Belvoir, Virginia 22060

by:

Planning & Management Consultants, Ltd.
808 West Main
P.O. Box 927
Carbondale, Illinois 62901
(618) 549-2832

under:

Contract No: DACW72-82-M-0160

February 1981

IWR Contract Report Report 82-C1

ACKNOWLEDGMENTS

In every stage of development, the illustrative examples benefited from the constructive criticism of numerous persons. Special recognition, for their enthusiastic and generous support of this process, is due the following U.S. Army Corps of Engineers personnel:

James Crews	William Pearson
Donald Duncan	William Porter
Kyle Schilling	W. H. Worthington

Additional valuable assistance was also provided by other U.S. Army Corps of Engineers personnel listed below:

George Baer	Ted Hillyer
Lawrence Bergen	William Johnson
Edward Cohn	Gary McMichael
John Cullinane	Robert Nordstrom
Edward Dickey	Stuart Piken
Dennis Duke	Edgar Story
C. T. Garvey	Daniel Sturman
Beverly Getzen	W. R. Summit
Vernon Hagen	Harry Walton
Robert Harrison	Richard Waugh

Finally, many aspects of the production of this manual would have been virtually impossible without the dedicated and capable contractor-support of the following persons:

Duane Baumann	Bonnie Kranzer
John Boland	Stan Lieber
Philip Carver	Pam Matlock
John Sims	Barbara Pearson
Kirk Alley	Jerry Reynolds
Cindy Frazer	Anne Sharpe
Nancy Baumann	Neil Smith
Dan Irwin	

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CHAPTER I

PURPOSE OF ILLUSTRATIVE EXAMPLES

OVERVIEW OF REPORT

The complete report on the development and evaluation of water conservation proposals is presented in two volumes. Volume I consists of proposed planning procedures which, if adopted, would facilitate and standardize the preparation of water conservation proposals for projects supplying water to municipal and industrial users. The procedures cover both formulation and analysis of individual water conservation measures, and the combination of those measures to form alternative water conservation proposals. These alternative proposals are the water conservation elements of alternative water supply development plans, including those which: (1) maximize the net contribution to the National Economic Development objective (the NED plan), (2) maximize the net contribution to the Environmental Quality objective (the EQ plan), and (3) reflect significant tradeoffs between the NED and EQ objectives (other plans).

Since the U.S. Army Corps of Engineers' previous experience in water supply planning has been limited to evaluation and implementation of supply-side strategies only, many aspects of what is essentially demand-side management will be unfamiliar to field planners. It is for this reason that Volume II has been prepared, consisting of accounts of illustrative applications of the proposed procedures under two rather different sets of circumstances. While these illustrative applications are based on data from the Atlanta, Georgia, and Tucson, Arizona metropolitan areas, <u>they include hypothetical as well as actual data, and do not represent complete applications in either locality. Neither illustration should be construed, therefore, as a water conservation study; they merely illustrate the application of proposed procedures under more or less realistic circumstances</u>.

In the course of preparing the proposed procedures, and of performing the illustrative applications of the proposed procedures, a number of strengths and weaknesses of the methods being used became evident. Since this constitutes the first attempt by a Federal agency to develop a standard approach to planning for water conservation, an area where even <u>ad hoc</u> methods have had limited application, it seems reasonable to regard the present effort as a part of a continuing development.

ROLE OF ILLUSTRATIVE EXAMPLES

The illustrative examples described in this volume consist of the application of the proposed procedures to two different sets of planning conditions. These conditions generally reflect those actually present in the summer of 1979 in the Atlanta, Georgia, and Tucson, Arizona

metropolitan areas. While every effort has been made to keep the applications as realistic as possible, the compressed time frame of the study did not permit absolute fidelity to actual local conditions. Certain data, therefore, are hypothetical; they are provided by the investigators where actual data were not readily available, or would have led to analyses different from those being demonstrated.

The applications are not intended to develop, and do not develop, water conservation proposals for the two communities. Rather, they illustrate the application of certain of the proposed procedures in a realistic setting. Even if all data were actual, the development of water conservation proposals requires the systematic consideration and evaluation of each applicable conservation measure, so that the plan selected can be the combination of individual measures which is, in some sense, "best." No attempt has been made to do this. <u>The illustrative applications are provided to illustrate process, not substance</u>. They show methods, approaches, techniques; they do not show results or conclusions.

CHAPTER II

SCOPE OF ILLUSTRATIVE EXAMPLES

Studies described in this report were performed between June and September, 1979. The data were obtained from state, regional, and local agencies, from U.S. Army Corps of Engineers Urban Study Teams, and directly by the investigators. Functionally, the work was performed in three phases: (1) preparation of site descriptions and lists of applicable water conservation measures; (2) social acceptability studies; and (3) measurement of advantageous and disadvantageous effects. These phases are discussed below.

SITE DESCRIPTIONS

Relatively extensive site descriptions are presented for both Atlanta and Tucson. At the time of the study, Urban Study projects were in progress in both cities, and the site descriptions draw heavily on material that had already been assembled by Corps staff. Additional information was sought, principally relating to climate, water use patterns, water conservation practices, and existing water supply and wastewater disposal systems.

The purpose of the site descriptions is to provide the necessary foundation and background for water conservation planning efforts and, more specifically, to permit the identification of applicable water conservation measures. Determinations of applicability and, to a lesser degree, technical feasibility, are strongly influenced by local conditions, habits, and traditions.

The site descriptions, as presented here, are likely to be excessively detailed and lengthy. Prior to the performance of the actual studies, it was impossible to predict which types of information would prove relevant, and which not. As experience with water conservation studies accumulates, more limited specifications for site description can be drawn, confining future efforts to those categories of information most likely to be useful.

SOCIAL ACCEPTABILITY STUDIES

Paradoxically, a water conservation measure that is technologically possible, effective, and economical will nevertheless sometimes fail to be implemented. Investigation into the reasons behind the downfall of what had appeared so promising will often reveal an unsuspected ideological conflict. That is, the conservation measure was perceived as violating some value held by some power in the community and therefore was defeated. For example, it may have been seen as constituting a discriminatory tax on homeowners or as interfering with free enterprise,

or as dangerously increasing the role of state or federal authorities in local affairs.

It is clear that whatever objective advantages may be claimed for a given conservation measure, that measure must, if it is to have any chance of success, also be congruent with the "social ideologies"--the values, beliefs and attitudes--of those who hold the power of decision. It follows that determining the social acceptability of a conservation measure requires knowledge of the principal ideologies that characterize a given community.

Efforts to delineate those community values of most relevance to water conservation in each of two sites, Atlanta and Tucson, are described in this report. In each case, U.S. Army Corps of Engineers staff first identified "community advisors," individuals known to the Corps to be highly knowledgeable about their city--its citizenry, its economy, and its politics.

Second, the investigators met with these advisors and through them identified those general environmental issues of most concern to the community, and those community powers (organizations and individuals) most involved in these issues. In effect, this step selected a group of "influentials," and prepared an agenda of environmental issues, the discussion of which promised to yield insight into the community's social ideologies.

The next step involved choices as to how to carry on such a "discussion" with the community. Two samples of community residents were selected and a different survey instrument designed for each. An Interview Guide was developed to direct one-on-one discussion with a small selection of those individuals which the informants had identified as exerting major influence in the city. This sample included representatives of such groups as the Chamber of Commerce, banking interests, homebuilders associations, unions, elected officials, conservation groups, citizen groups, and so on. Also, a mail questionnaire was designed to survey the opinion of a larger sample of the ultimate community influence, the general public. Both instruments incorporate into the content of their inquiry those environmental issues that advisors identified as figuring importantly in community affairs.

These instruments, the Interview Guides and Survey Questionnaires for Atlanta and Tucson, are presented in detail in Appendix A and B, respectively. It is sufficient here to call attention to a few points:

1. Several issues are identified as being extremely relevant to both Atlanta and Tucson--foremost among these is the question of urban growth; another is the question of possible jurisdictional conflicts in the implementation of conservation policies and programs. Questions devoted to the examination of such issues appear in the instruments for both cities.

2. A number of specific representative conservation measures were also examined in both Atlanta and Tucson on the logic that the range of possible conservation measures should be explored in each city, notwithstanding the limited scope of the present study.

3. A number of site specific issues, pertinent only to either Atlanta or Tucson, are incorporated into the appropriate instruments; thus, the Atlanta instruments included mention of proposals for increasing Atlanta's water supply from the Chattahoochee River, and the Tucson instruments explored questions on Indian water rights and the Central Arizona Project.

Once the two instruments were prepared for each city, the processes of data collection began. A packet, which consisted of a letter explaining the general purpose and requesting cooperation, a questionnaire, and a stamped, return envelope, was mailed to samples drawn randomly from metropolitan telephone books.

Letters requesting an interview were also sent to the sample of community influentials. These letters included calendars of available dates, times, and places from which they could select an appointment most convenient to them. Following the interviews, another letter was sent expressing appreciation for assistance. Examples of the initial letter, the appointment calendar, and the final letter are presented in Appendix C.

These two kinds of data--the qualitative, relatively open-ended hour-long discussions with representatives of community powers, and the quantitative responses of the public on the structured questionnaire--are analyzed and interpreted to the dual end of providing (1) an overall view of those aspects of ideology most relevant to understanding community response to water conservation measures and (2) a measure of community evaluations of a sample of specific conservation measures.

BENEFIT-COST ANALYSIS

Following determination of applicable measures which appear to be technically feasible and socially acceptable, it is necessary to identify and measure advantageous and disadvantageous effects so that optimal water conservation proposals can be developed. This requires that implementation conditions be investigated for each measure, implementation costs be determined, effectiveness be estimated, and the foregone costs that result from reduced water use be measured.

Because of the limited time and resources available for this study, the scope of the investigation is severely narrowed at this point. While preceding steps identified several dozen types of potential measures, only a handful are chosen for further investigation. For example, in Atlanta only five measures are analyzed, one of which will prove infeasible. An attempt is made to choose specific measures that

illustrate a range of analytical techniques, but all possible approaches cannot be treated.

As shown below, effectiveness estimates are based on disaggregated forecasts of future water use. Such forecasts imply the existence of records of current water use that are disaggregated by user category. One reason for selecting Atlanta and Tucson as study sites is the immediate availability of disaggregated water use data. Relatively few communities routinely perform such analyses. Where no records of this kind exist, they must be prepared before effectiveness determinations can be made. This can be accomplished by coding customer accounts by category, then accumulating, for at least one year, water use observations keyed to the coded categories. Time limitations did not permit demonstration of this procedure in the study reported here.

Determination of the supply cost/water use reduction relationships, needed for measurement of foregone costs, has been based on analysis of the operating budgets of the respective water utilities. Had more time been available, a more detailed analysis, similar to a marginal cost of service study, might have provided more reliable benefit estimates. Similarly, implementation costs are estimated from data given in the literature, rather than from specific analysis of local conditions.

Sources of data and assumptions are given in the text wherever possible. Statements such as "it is assumed that" or "for purposes of illustration, this will be taken as" indicate cases where hypothetical data have been inserted. This practice is used sparingly, only where limitations placed on the study do not permit a reasonable estimate of the actual value. Still, because hypothetical data are used, and because of the simplifications and assumptions discussed above, it should again be noted that the results of the analyses shown here do not apply to any actual location, and should not be inferred as necessarily relevant to either Atlanta or Tucson. What follows are illustrative examples intended to assist field planners in interpreting the proposed procedures; they are not water conservation studies.

ATLANTA DATA

CHAPTER III

GENERAL SITE DESCRIPTION: ATLANTA, GEORGIA

INTRODUCTION

The city of Atlanta is located in the Piedmont region of north-central Georgia. The Atlanta planning region, under the jurisdiction of the Atlanta Regional Planning Commission (ARC), is comprised of seven counties: Clayton, Cobb, DeKalb, Douglas, Fulton, Gwinnett, and Rockdale, containing 45 incorporated municipalities, a total population of over 1,600,000 and covering 2,064 square miles.

The Atlanta Standard Metropolitan Statistical Area (SMSA) consists of 15 counties, with over 90 percent of the population living within the confines of the seven counties stated above (Figure 1). The city of Atlanta lies predominantly in Fulton County, the most populous of the seven counties (Figure 2).

HISTORICAL GROWTH AND DEVELOPMENT

Atlanta owes its beginning to a decision by the General Assembly of Georgia in 1836 to establish rail links with Tennessee. The Atlanta area, being situated at the confluence of several ridges and wilderness roads, was selected as the terminal site. Originally named Terminus, it then became Marthasville and was finally named Atlanta in 1845. In 1847 a city charter was adopted, and in 1857 the city was incorporated.

With the development of the railroads and their convergence on Atlanta, the area grew and prospered. In 1865 the city was burned to the ground by General Sherman. The city rebuilt its economy and today is one of the fastest growing cities in the country.

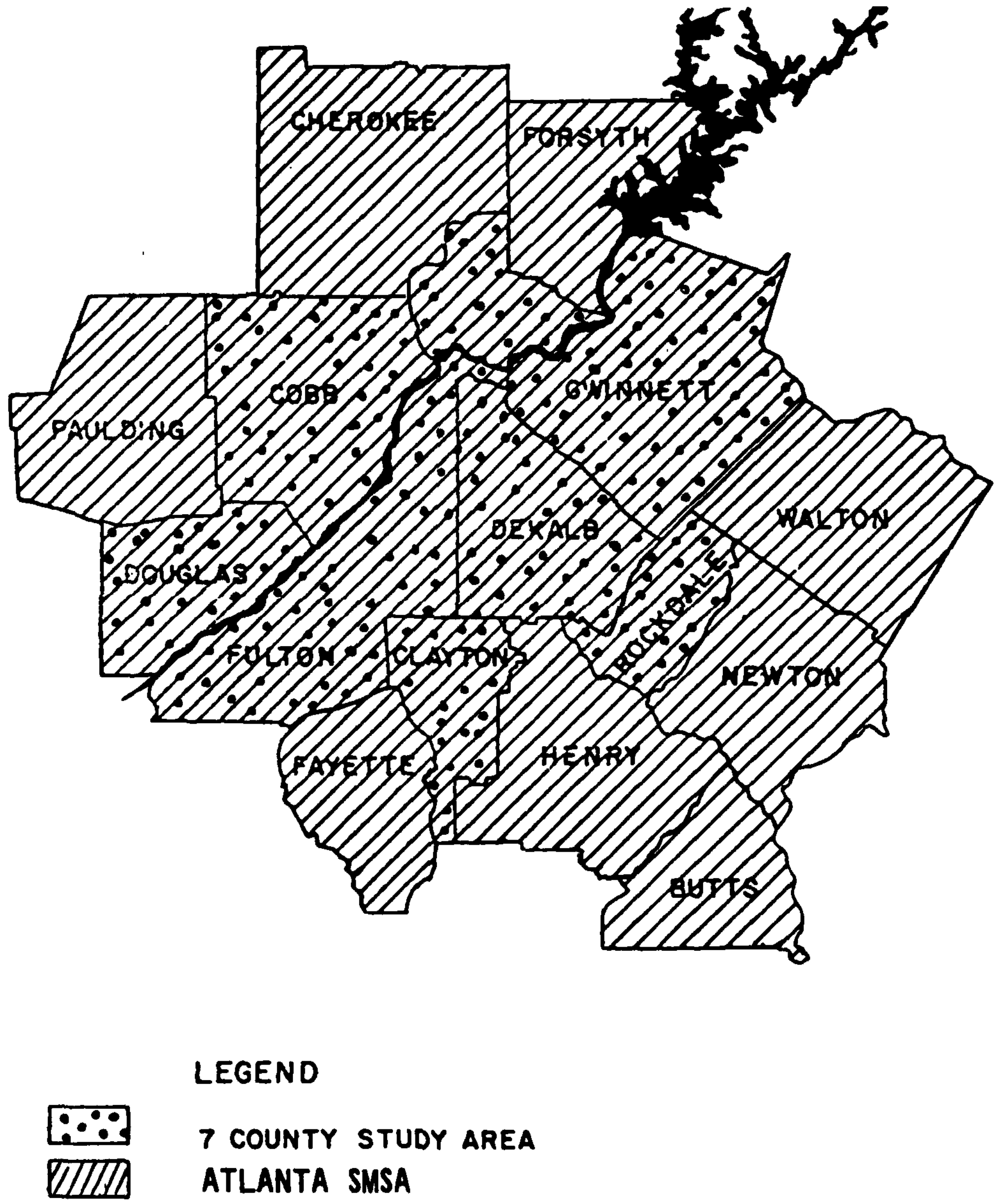
Because of its role as a transportation center, Atlanta's economy has maintained a diversified base. During the 1960s investments in convention-related facilities fostered growth in business, cultural, and recreational areas. This development coincided with growth in shopping centers, offices, industrial parks, and freeways. The city dominates the southeast in wholesaling and is continuing to grow as a national retail trade center. Atlanta is also the county seat of Fulton County, the state capital and the location of regional offices for many state and federal agencies and two state universities.

POLITICAL STRUCTURE

The seven-county region contains 45 municipalities and 45 other local governments, special districts, and school districts with local governing powers. Over 85 percent of the municipal governments have

FIGURE 1

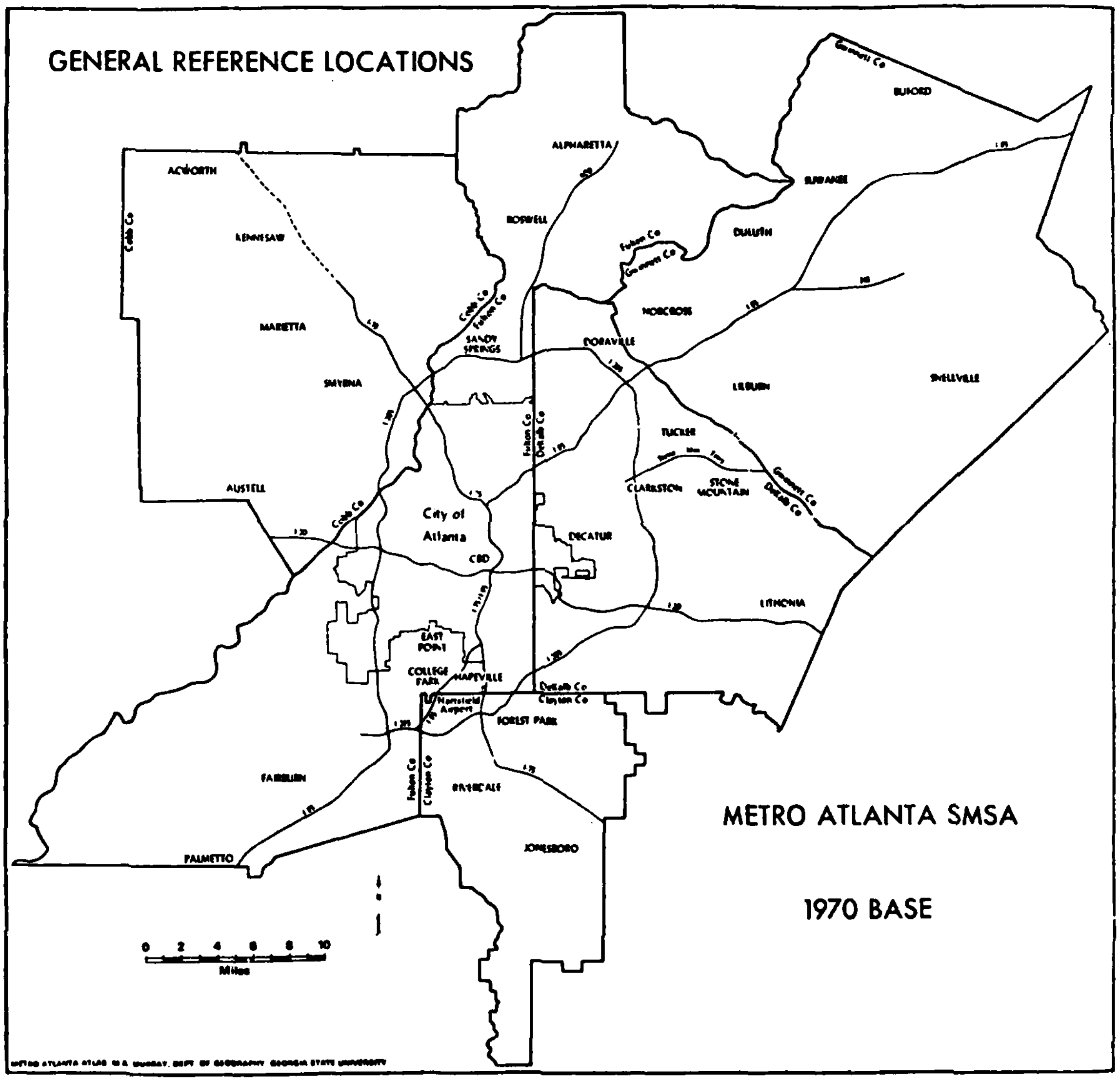
THE FIFTEEN-COUNTY STATISTICAL AREA



Source: U.S. Army Corps of Engineers, Appendix D, (1978).

FIGURE 2

THE ATLANTA SMSA



elected mayors and councils. Over one-third of them maintain a city manager who oversees the local government operations and services. These operations and services include police and fire protection, and recreational, water, sewer, and sanitation services.

The county governments are governed by elected county commissions, with their chairmen serving as Chief Administrative Officers. The counties provide additional services such as civil defense; education; public health; libraries; parks and recreational programs; police and fire protection; and water, sewer, and sanitation services.

Several countywide or larger systems provide water supply and wastewater treatment services. Municipalities are generally responsible for water distribution and sewage collection services within their boundaries (Figure 3). A board comprised of elected county officials and citizen representatives provides the local decision making in water resources and monitor the decisions and actions of the water managers.

The Atlanta Regional Commission, begun in 1971, is the official area planning and development commission for the seven county region. It is made up of both elected officials and appointed citizens and serves as a coordinating agency to the local governments and their citizens. Other nearby planning agencies are the Georgia Mountains Area Planning and Development Commission, the Chattahoochee-Flint APDC, and the McIntosh Trail APDC. These regional planning commissions have no direct power for implementation of plans, but serve as regional sources of guidelines and recommendations.

PHYSICAL CHARACTERISTICS

Topography

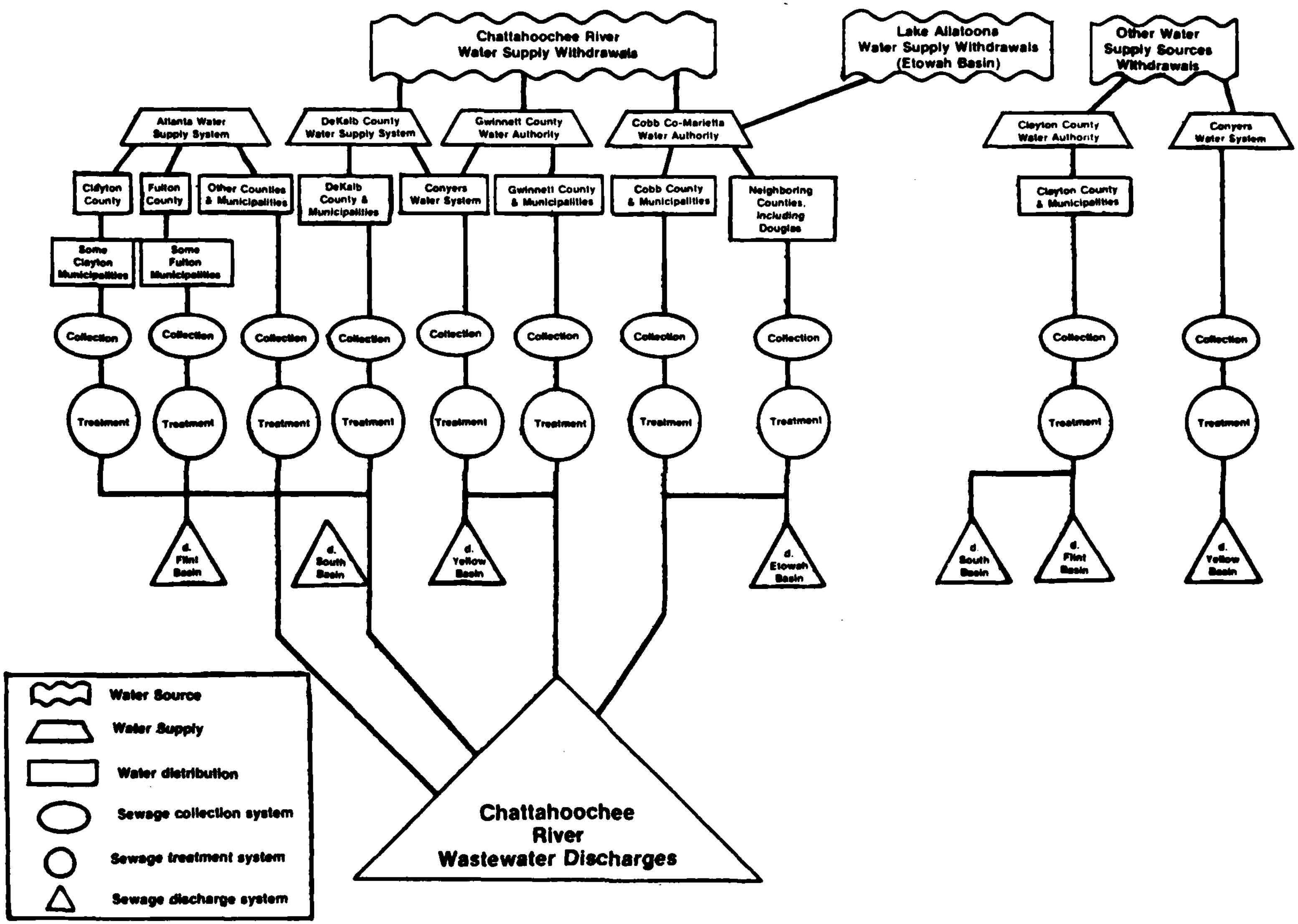
The Atlanta region is situated in the Piedmont upland which is bounded on the north by the Appalachian Valley and Blue Ridge Provinces and bounded on the south by the coastal plain. The average elevation is approximately 1,000 feet above sea level.

The major physiographic feature of the area is the Chattahoochee River which flows from the Georgia Blue Ridge Mountains north of Atlanta westward around the city, continuing south to join the Flint River near the Florida border to form the Appalachicola River. The Appalachicola, in turn, empties into the Gulf of Mexico. The Chattahoochee is the longest river in Georgia, draining 1,450 square miles of mountains and Piedmont country.

The Atlanta urban area is located on the top of a divide, Peachtree Divide, which separates two major drainage systems. The northern and western sides of the area drain directly into the Chattahoochee; the southern area drains into the Flint River; and the eastern slopes feed the Ocmulgee-Altamaha river system via the South, Yellow, and Alcovy rivers (Figure 4).

FIGURE 3

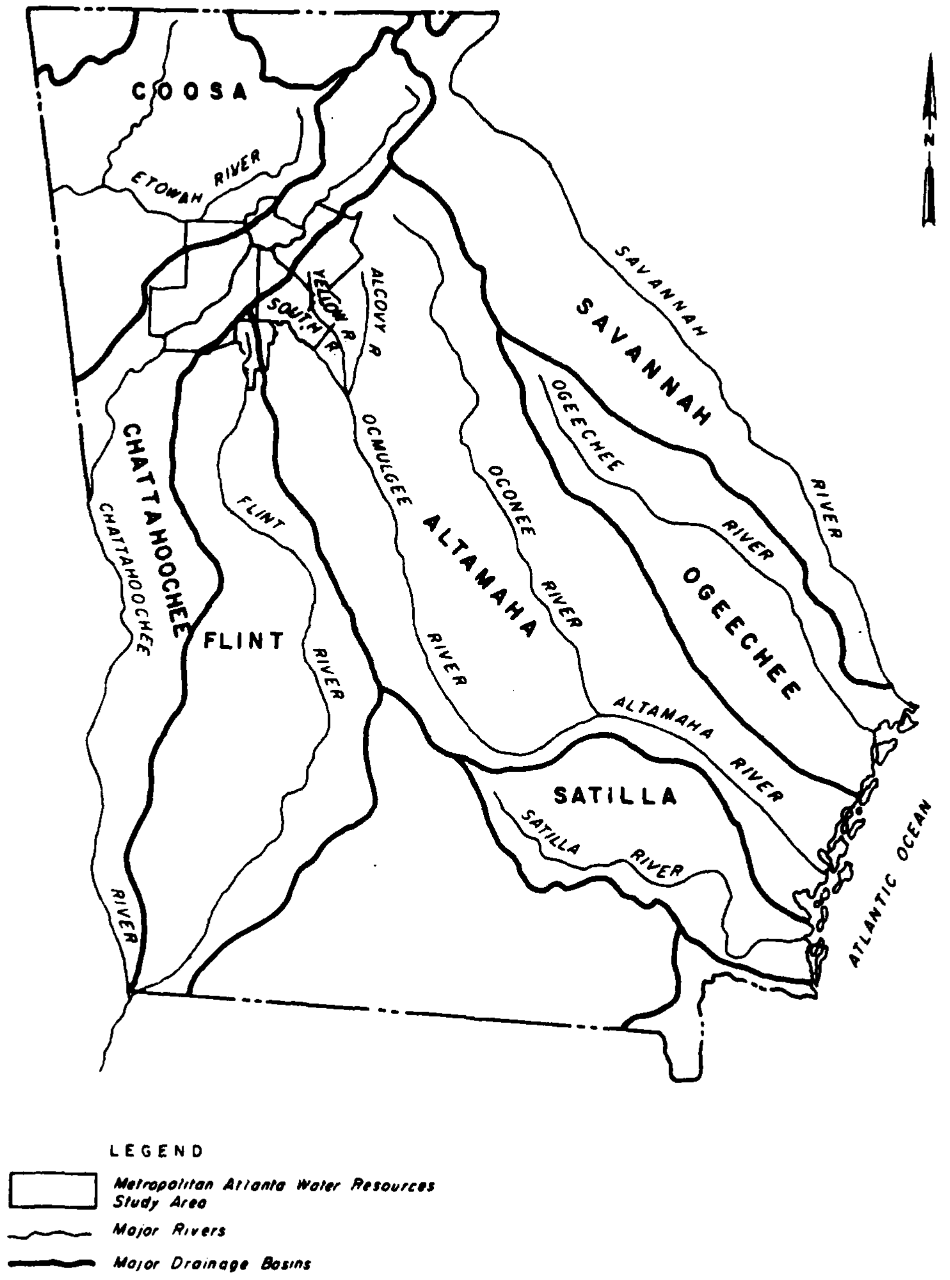
WATER AGENCY & FLOW RELATIONSHIPS, ATLANTA REGION



Source: U.S. Army Corps of Engineers, Appendix D, (1978).

FIGURE 4

MAJOR RIVER BASINS



Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

Climate

The climate of the area is described as humid and continental (U.S. Army Corps of Engineers, Appendix A, 1978), having mild winters and variable temperatures. The average summer temperature is 78.6 degrees farenheit. The normal frost free period is March 29 to November 8. The altitude and latitude of the region combine to keep the summers relatively moderate.

The average winter temperature is 45.5 degrees farenheit. The winter season is characterized by prevailing northerly winds and frequent alterations of warm moist southerly winds and colder dry northerly winds.

Precipitation is fairly well distributed throughout the year and averages 48 inches a year. Annual totals are seldom less than 32 inches or more than 68 inches. Evaporation and evapotranspiration average 30 inches per year, leaving approximately 18 inches for ground and surface waters. Approximately one-half of the annual rainfall occurs in quantities of one inch or more within a 24-hour period. Winter storms are generally extensive, steady, and 2-3 days in duration. The summer storms are more localized, intense, and brief.

DEMOGRAPHY

1975 the Atlanta Regional Commission published "An Economic Base Study of the Atlanta Region" (ARC, March, 1975). It is this document and the socio-economic projections within it that formed the basis for the consequent "Regional Development Plan" (ARC, 1976). These data also provided the basis for most of the research and analysis for the "Metropolitan Atlanta Area Water Resources Management Study" (U.S. Army Corps of Engineers, 1978). Figure 5 and Table 1 show the current and projected areawide and county populations as compiled by the Atlanta Regional Commission. These are the most recent projections furnished by the "RDP Alternative E" (ARC, January, 1976).

Population Projections

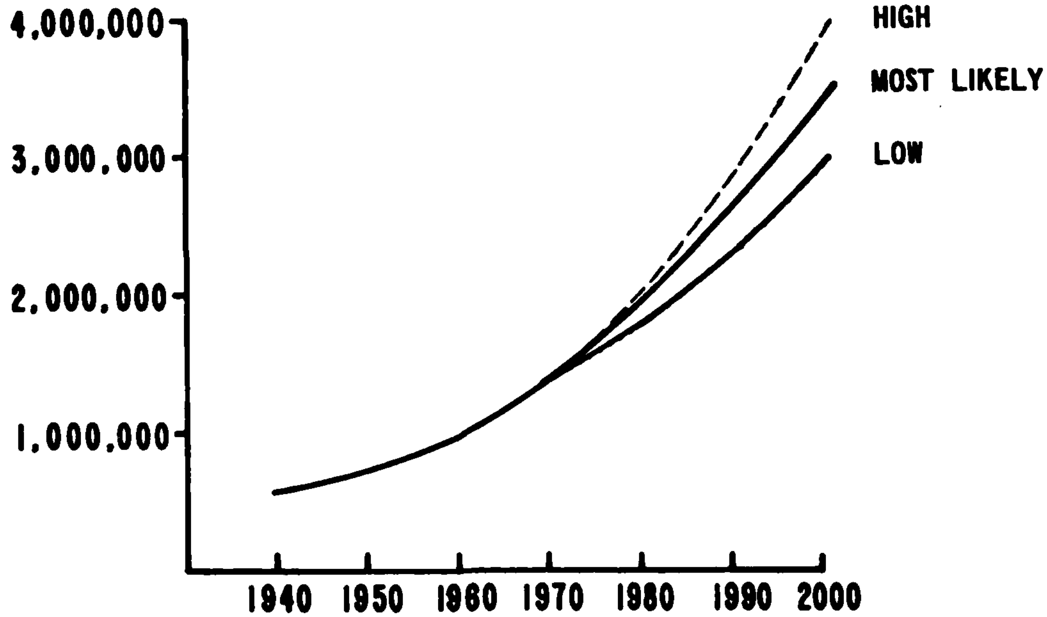
The total population of the Atlanta region, approximately 1,600,000 at present, is projected to increase 142.1 percent between 1970 and the year 2000 (Figure 5). It is expected to reach 2 million in the early 1980s and 3 million by the mid 1990s (ARC, March, 1975). Tables 2 and 3 show population growth as experienced in the past and as projected to the year 2000. The Atlanta SMSA ranked eighth in 1960-1970 growth rate among metropolitan areas of population greater than one million.

Employment

Projected employment trends for the Atlanta region are found in Table 4. The ARC (March, 1975) believes that employment will reach over 1.5 million by the year 2000.

FIGURE 5

HISTORIC AND PROJECTED POPULATION



Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

TABLE 1

ATLANTA REGION POPULATION PROJECTIONS

	Alternative E					OBERS
	1970	1975	1980	1990	2000	2000
Atlanta	496,156	481,659	475,256	526,329	580,992	
Fulton	109,426	145,598	202,272	349,343	500,628	564,200
DeKalb	415,387	462,248	538,391	681,369	788,965	764,800
Cobb	196,793	246,785	328,992	463,524	611,998	415,550
Clayton	98,043	126,241	170,896	234,577	332,757	279,900
Gwinnett	72,349	111,110	174,892	265,757	384,206	275,100
Rockdale	18,152	26,648	40,163	69,982	116,135	47,800
Douglas	28,659	40,182	59,019	92,197	153,150	100,900
Henry (Part)	6,922	9,075	11,904	21,487	36,286	---
TOTALS	1,441,855	1,649,502	2,001,732	2,704,565	3,505,051	2,448,200

Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

TABLE 2

POPULATION GROWTH ATLANTA REGION:
1900-1970

Year	Number of Persons	Ten Year Increase Number	Ten Year Increase Percent
1900	230,053	--	--
1910	309,270	78,317	33.9
1920	387,172	77,902	25.2
1930	495,727	108,555	28.0
1940	576,619	80,892	16.3
1950	747,626	171,007	29.7
1960	1,044,321	296,695	39.7
1970	1,436,975	392,654	37.6

The figures above from 1900 through 1970 include all seven metropolitan counties (Clayton, Cobb, DeKalb, Douglas, Fulton, Gwinnett, and Rockdate) and, in addition, figures for 1930 and previous years include old Milton and Campbell counties which were annexed to Fulton County in 1932.

Source: Atlanta Regional Commission (March, 1975).

TABLE 3

ANTICIPATED AVERAGE ANNUAL INCREASE IN NUMBER
OF PERSONS AND PERCENT INCREASE PER DECADE
ATLANTA REGION
1970-2000

Year	Number of Persons Per Year	Percent Increase Per Decade
1970	39,270	37.6
1980	55,430	38.6
1990	69,590	34.9
2000	79,130	29.4

Source: Atlanta Regional Commission (March, 1975).

TABLE 4

EMPLOYMENT TRENDS
(1000)

	1970	2000
Manufacturing	123.8	291.9
Trade[1]	169.7	427.4
Services	94.3	284.0
Government	95.8	230.6
Other[2]	137.8	345.9
Total Employment[3]	621.4	1,579.8

[1] Includes wholesale and retail trade.

[2] Includes transportation, communications, utilities, finance, insurance, real estate, construction, and mining.

[3] Total civilian nonfarm wage and salary employment for the seven counties.

Source: U.S. Army Corps of Engineers, Appendix D (1978).

During the 1960-1970 period, employment showed the greatest absolute growth in manufacturing and retail trade, and the greatest growth rate in government, services, and retail trade (ARC, March, 1975). The ARC, in assuming a growing population with increased income and business service demands, believes the region will continue to experience growth in services, finance, insurance, and real estate jobs. The service industries will exhibit the highest rate of growth with an estimated 201.2 percent increase between 1970 and 2000. In sum, the Atlanta region will continue to specialize in wholesale trade, followed by transportation, communication, and utilities, and these will be followed by finance, insurance, and real estate.

Income

The median family income in the Atlanta region exceeded the national median income for the first time in the 1960s, reaching $10,620 in 1969. In general, the region is composed of relatively affluent families. Table 5 shows the ARC's income projections (March, 1975) to the year 2000. These projections indicate that real median family income will more than double by the year 2000.

Housing

The housing forecasts for the Atlanta area are found in Table 6. The ARC projects that the average household size will continue to decrease from 3.42 persons per dwelling in 1960 to 2.83 in the year 2000. Additional housing characteristic data are found in Table 7.

Education

The median school years completed by Atlanta residents was approximately 12 years in 1970. Table 8 furnishes supplemental educational information.

In-Migration and Racial Composition

The ARC reports (March, 1975) that 54.7 percent of the Atlanta area's population growth between 1960 and 1970 can be accounted for by in-migration. The Commission also believes that this net in-migration will continue to be the prime contributor to the Atlanta region's population growth.

Data on the racial composition and net migration of DeKalb and Fulton counties and the city of Atlanta are available in Table 9. Foreign stock or ethnic minorities (other than black) contribute only a small percentage of the total population.

The black population is both substantial and variable, making up 51.5 percent of the population in the city of Atlanta and only 13.7 percent in DeKalb County.

TABLE 5

DISTRIBUTION OF FAMILIES BY INCOME RANGE: ATLANTA REGION
1970-2000

Income Range (DOLLARS)	1970	Percent of Total	1980	Percent of Total	1990	Percent of Total	2000	Percent of Total
Less than 3,000	29,903	8.2	27,113	5.0	16,435	2.2	0	0.0
3,000 to 4,999	29,538	8.1	30,240	5.6	25,170	3.4	6,977	0.7
5,000 to 6,999	38,290	10.5	42,671	7.9	39,678	5.4	26,882	2.8
7,000 to 9,999	70,017	19.2	79,438	14.8	72,929	10.0	48,129	5.1
10,000 to 11,999	47,042	12.9	64,086	11.9	75,857	10.4	81,193	8.6
12,000 to 14,999	56,524	15.5	78,573	14.6	97,679	13.3	114,111	12.1
15,000 to 24,999	72,205	19.8	125,619	23.4	196,652	26.9	286,564	30.3
25,000 to 49,999	17,504	4.8	72,131	13.4	162,739	22.2	294,551	31.1
50,000 or more	3,647	1.0	18,204	3.4	44,954	6.2	87,982	9.3
Total	364,670	100.0	538,075	100.0	732,093	100.0	946,389	100.0
Median Income of Families	$10,620		$12,953		$16,953		$21,843	

Source: U.S. Bureau of the Census and Atlanta Regional Commission (March, 1975).

TABLE 6

POPULATION AND HOUSEHOLDS: ATLANTA REGION
1960-2000

	1960	1970	1980	1990	2000
Total Population	1,044,321	1,436,975	1,991,342	2,687,213	3,478,450
In Group Quarters	23,844	25,354[1]	29,800	35,400	41,600
In Households	1,020,477	1,409,263	1,961,542	2,651,813	3,436,850
Households	298,518	442,813	670,625	927,689	1,214,717
Families	(260,329)	(364,670)	(538,075)	(732,093)	(946,389)
Individuals	(38,189)	(78,143)	(132,550)	(195,596)	(268,328)
Average Household Size	3.42	3.18	2.92	2.86	2.83

[1] Numbers do not add to total population because of census errors of estimate.

Source: U.S. Bureau of the Census and Atlanta Regional Commission (March, 1975).

TABLE 7

HOUSING STATISTICS (1970)

	Owner Occupied (PERCENT)	Lacking Some or All Plumbing Facilities (PERCENT)	Median Value Owner Occupied Single Family (DOLLARS)	New Housing (1975-76) Single Units (PERCENT)
DeKalb County	64.4	1.2	22,391	96.7
Fulton County	45.7	2.4	19,389	72.7
City of Atlanta	41.1	1.9	17,315	28.2

Source: U.S. Bureau of the Census, County and City Data Book (1972 and 1977).

TABLE 8

EDUCATION STATISTICS
(PERSONS 25 YEARS OR OLDER, 1970)

	School Years Completed (PERCENT)			
	Less than 5 Years	4 Years High School or More	4 Years College or More	Median Years Completed
DeKalb County	3.6	63.8	19.3	12.5
Fulton County	7.9	49.9	14.5	12.0
City of Atlanta	9.0	46.5	13.0	11.5

Source: U.S. Bureau of the Census, County and City Data Book (1972).

TABLE 9

RACIAL COMPOSITION AND NET MIGRATION (1970)
(PERCENT)

	Black Population	Foreign Stock	Spanish Heritage	Black Change 1960-70	Net Migration 1960-70
DeKalb County	13.7	5.3	1.3	+156.5	+ 42.1
Fulton County	39.1	3.7	<400	+ 22.5	- 4.0
City of Atlanta	51.5	3.5	1.0	+ 36.3	not available

Source: U.S. Bureau of Census, County and City Data Book (1972).

LAND USE

Data from the counties in the Atlanta planning region provide the basis for Table 10 which displays the current and projected land use categories by percentages.

WATER RESOURCES

Water Supply

The Atlanta region has three sources of water: the Chattahoochee River, small streams in the area, and groundwater. The latter two sources currently play a very minor role in water supply for the area, and they are not considered significant sources of supply for the future (U.S. Army Corps of Engineers, Appendix A, 1978).

The primary source of water for the region is the Chattahoochee River and Lake Sidney Lanier. This water source supplies over 90 percent of the water used in the region and can be seen in Figure 6. The Chattahoochee River drains 1,450 square miles of mountain and Piedmont regions before delivering its water within six miles of downtown Atlanta. The water quality is excellent at the Atlanta water intake and is classified as "drinking water" by the Georgia Department of Natural Resources.

TABLE 10

LAND USE CATEGORIES BY PERCENT
SEVEN-COUNTY PRIMARY STUDY AREA[1]

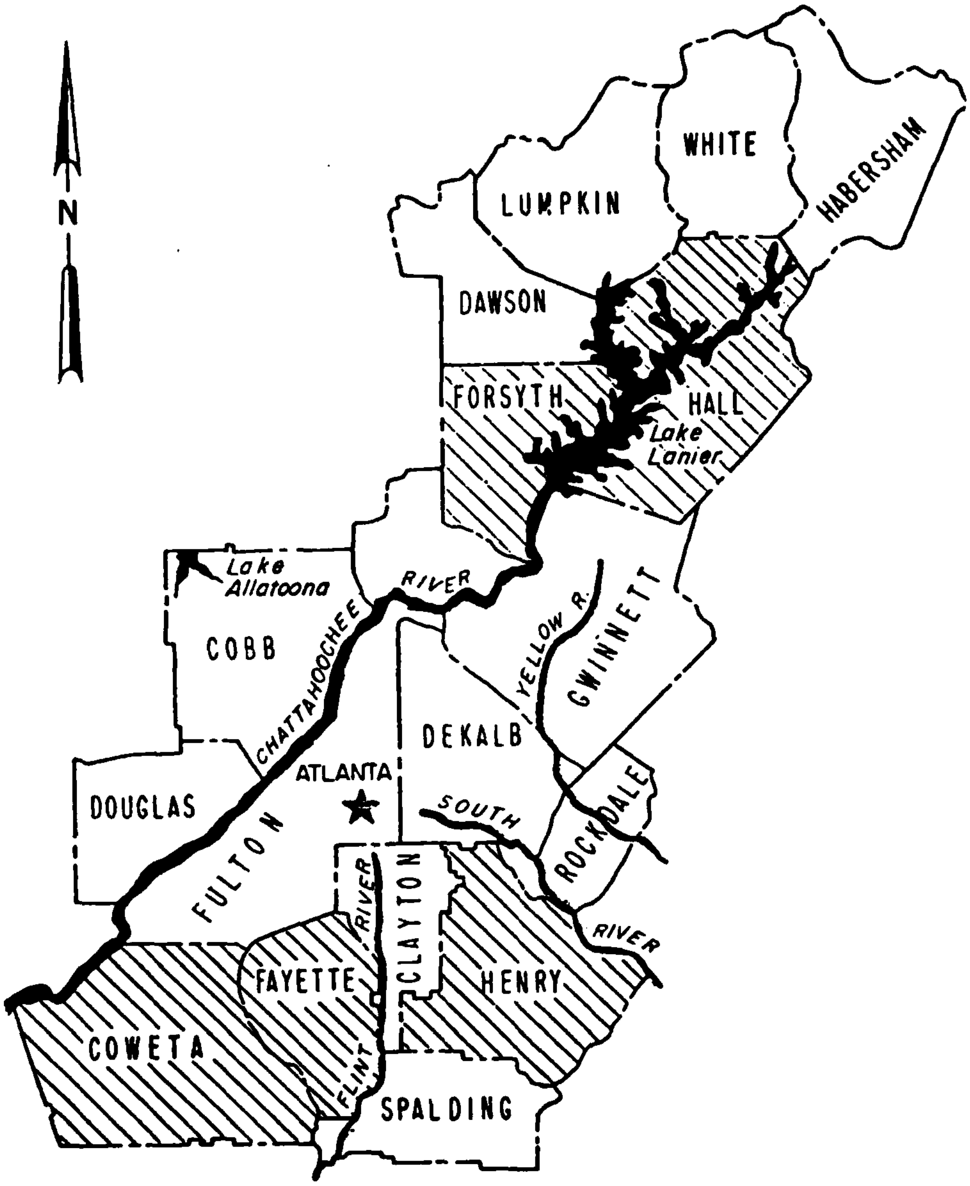
Land Use Category	1970	1980	1990	2000
Single Family	11	13	15	17
Multi-Family	1	2	3	4
Industrial	1	2	2	2
Commercial	1	1	2	3
Public	3	4	4	6
Rights-of-Way	5	6	7	8
Vacant	78	71	65	59

[1]Based on a total of 1,321,020 acres in the study area.

Source: Atlanta Regional Commission Development Plan, and
U.S. Army Corps of Engineers, Summary Report (1978).

FIGURE 6

PRIMARY SOURCE OF WATER FOR THE AREA



Source: U.S. Army Corps of Engineers, Summary Report (1978).

Buford Dam and Lake Sidney Lanier, multipurpose water facilities, are situated on the Chattahoochee River. The facilities, located approximately 35 miles northeast of Atlanta, began operation in 1956 for the Congressionally authorized purposes of flood control, navigation and power. The project (U.S. Army Corps of Engineers, Appendix B, Vol. 3, 1978) "reduced flood stages in the Chattahoochee River as far downstream as West Point, Georgia, 150 miles below the dam; provides increased flows for water supply low-flow augmentation, and navigation; produces hydroelectric energy operating as a peaking powerplant and provides increased production of hydroelectric energy at downstream hydroelectric powerplants during low flow seasons. The project is a major recreational facility of the Metropolitan Atlanta region." The U.S. Army Corps of Engineers Study (Appendix B, Vol. 3, 1978) states that the primary purposes of the project did not include water supply, but that this was considered as an incidental use attributable to the operation of the project.

Lake Sidney Lanier, at normal pool elevation of 1070 feet, has 38,000 surface acres and a total storage of 1,917,000 acre-feet. The Chattahoochee River flow is regulated by Buford Dam and by the hydropower generation at Morgan Falls Dam located 36 miles downstream from Buford Dam (Figure 7).

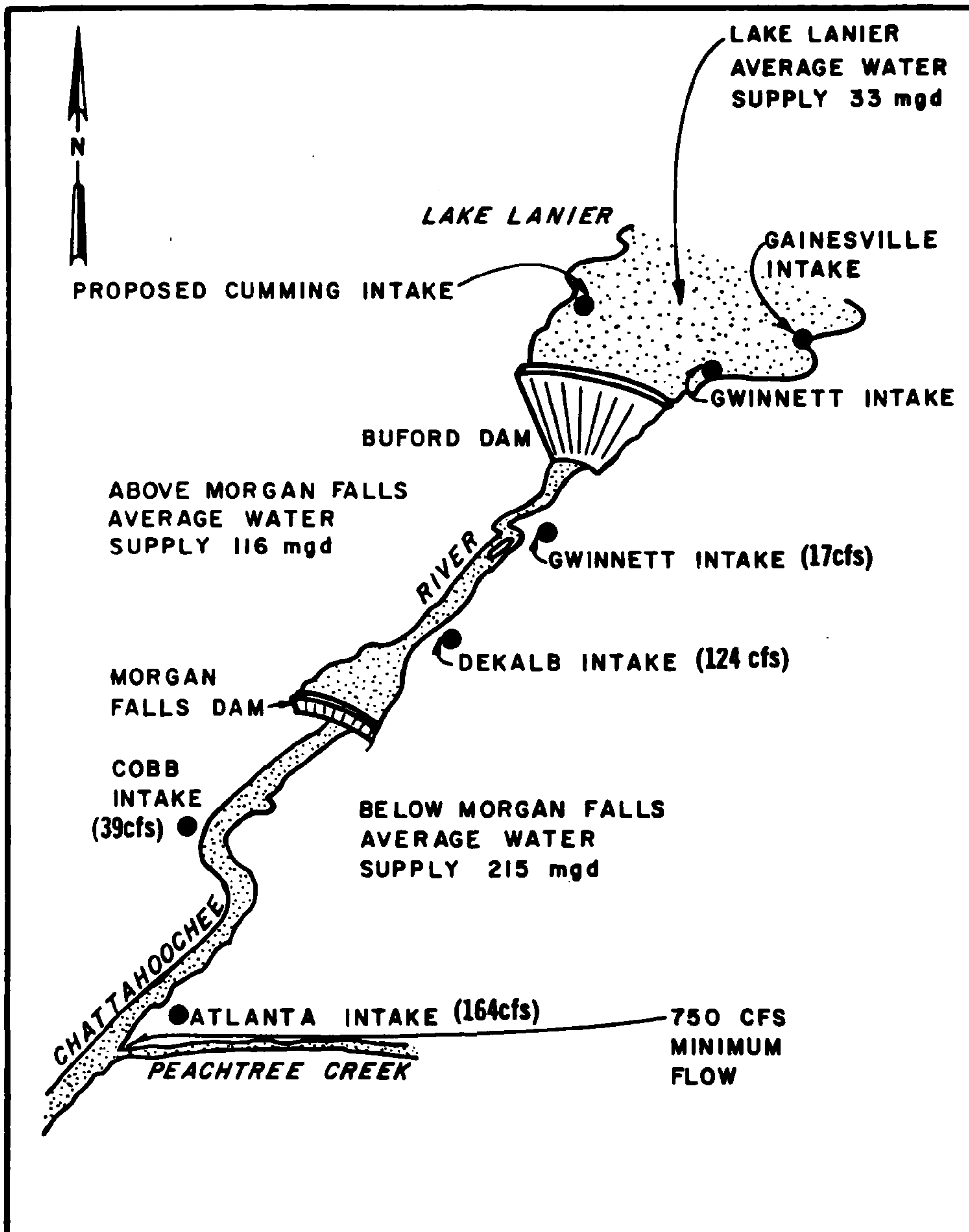
The lowest recorded annual rainfall of 31.8 inches occurred in 1954. Streamflows resulting from this rainfall form the basis of current water quality criteria (U.S. Army Corps of Engineers, Appendix B, Vol. 2, 1978). In 1974 the State Environmental Protection Division (EPD) issued a policy statement which prohibited future water withdrawals from the Chattahoochee River without commensurate additional flows being made available from Buford Dam as compensation. At present 1094 cfs is required to provide the Atlanta region with an ample water supply and to provide a minimum river flow to maintain water quality standards as specified by the state EPD. Figure 7 shows the present locations of water intake facilities along the Chattahoochee and Figure 8 illustrates the present river flow requirements. A minimum of 750 cfs is required at a point between the city of Atlanta and Peachtree Creek. This requirement insures a minimum water quality below the Atlanta region after receiving wastewater discharges.

It is estimated that a minimum local inflow of 50 cfs can be expected between Buford Dam and the Atlanta intake. The river also receives about 20 cfs of treated wastewater above Peachtree Creek.

According to the U.S. Army Corps of Engineers' Study (Appendix B, Vol. 3, 1978), the Atlanta region "will require more water by the year 2000 than can be presently obtained with existing water supply systems." Because the three major water users of the region, the city of Atlanta, Cobb and DeKalb counties required expansion of their facilities before a long range plan could be worked out, increased water allocations had to be provided to these three agencies. The Corps reports (Appendix D, 1978) that "requests from the city of Atlanta and DeKalb County for new water supply intake facilities along the Chattahoochee River were shelved until the study group could determine if there is actually enough water for these new intakes and existing uses as well." An interim water

FIGURE 7

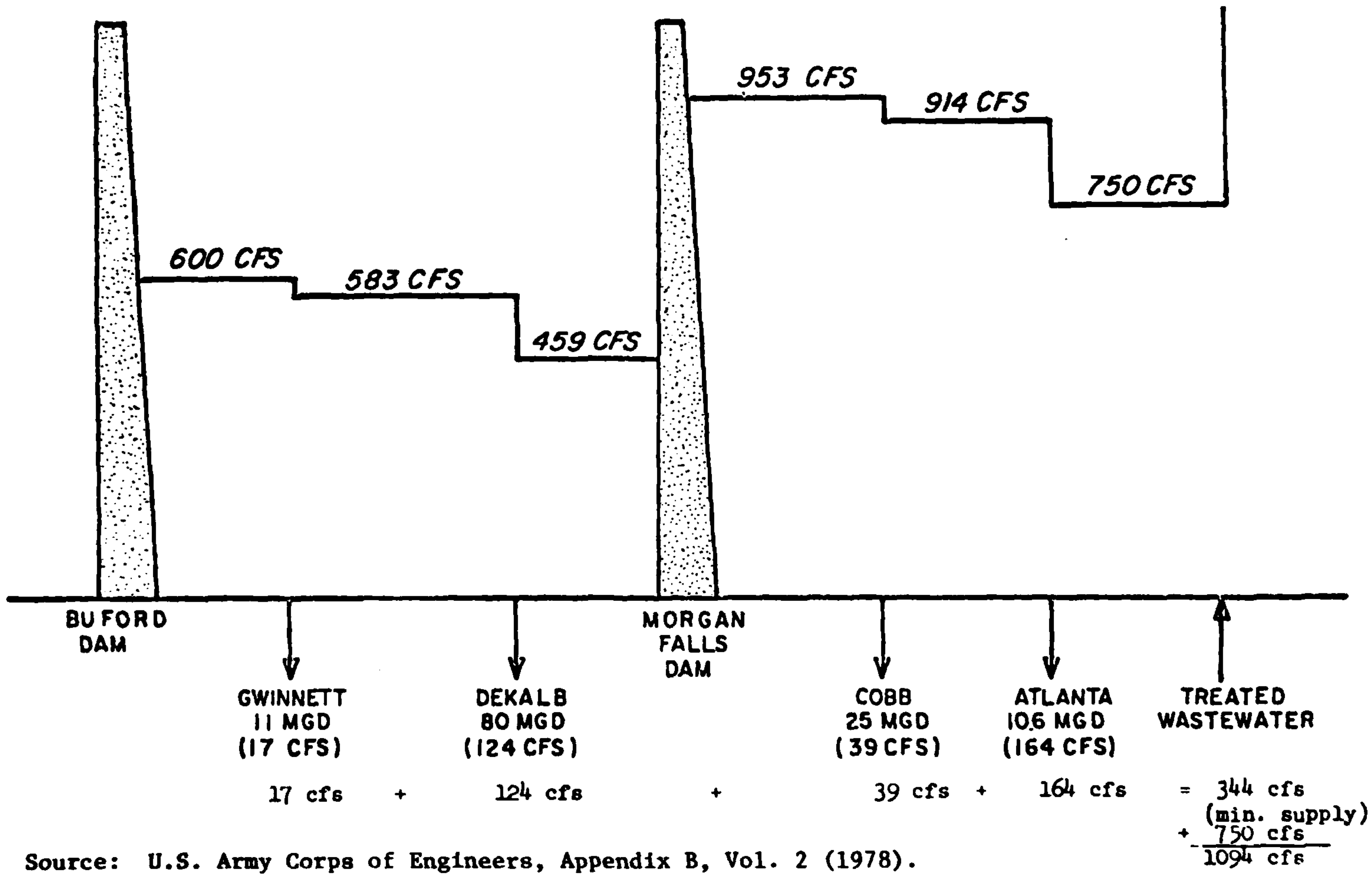
PRESENT MINIMUM SHORT-TERM WATER SUPPLY



Source: U.S. Army Corps of Engineers, Appendix B., Vol 2 (1978).

FIGURE 8

MINIMUM FLOW IN CHATTAHOOCHEE RIVER, 1974



Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

supply agreement was then arranged by altering the management of Buford Dam and Morgan Falls Dam to provide an average of 230 mgd of water supply. This plan is expected to provide for the area's water supply needs until 1985. From 1985 until approximately 1990, a proposed short-term plan will go into effect which will raise the elevation of Lake Lanier one foot to 1,071 feet. This plan should be operable by 1980 and will provide for the water supply needs of the region until approximately 1990. An average of 431 mgd will be needed for water supply by the year 2000. Table 11 depicts the proposed water allocations for the present, interim, short-term, and preliminary long-term plans.

In assessing the distribution of available water supply for the year 2000, the U.S. Army Corps of Engineers, (Appendix B, Vol. 2, 1978) reported that an "extensive analysis of the inflows and present operation procedures of Buford Dam over a 48 year period of streamflow records indicated that an average flow of approximately 1,800 cfs could be provided from Lake Lanier during a severe drought such as occurred in 1954." Using average daily withdrawal figures, the following computations provide the maximum water supply available from the Chattahoochee River in the year 2000:

Total Maximum Yield from Lake Lanier	=	1,800 cfs
Net Average Withdrawal from Lake Lanier	=	- 83 cfs
Maximum Average Releases from Buford Dam	=	1,717 cfs
Projected Wastewater Inflow below Buford Dam	=	+ 45 cfs
Maximum Average Flow in Chattahoochee River	=	1,762 cfs
Minimum Flow for Downstream Water Quality	=	-750 cfs
Maximum Water Supply from Chattahoochee River	=	1,012 cfs

As seen in Table 11 the maximum water supply of 1,012 cfs (described above) for the year 2000 barely exceeds the projected water supply withdrawals (1,000 cfs) from the river during the peak demand.

As of 1979, studies are underway to evaluate plans for meeting water supply needs in the Atlanta region beyond 1990. The options listed for further study include building a reregulation facility, raising the Lake's operating pool level, steady releases and combinations of these options (U.S. Army Corps of Engineers, Appendix B, Vol. 3, 1978).

Water Quality

The Georgia EPD has set water quality standards for streams in Georgia as specified in Section 391-3-6 .03 of the Georgia Water Quality Control Regulations. The standards are applied via a system of water use classifications that are designed to make the best use of each stream in Georgia based on an environmental and economic assessment. The water use classifications employed in Georgia are: Drinking Water Supply, Recreational, Fishing (propagation of fish, shellfish, and other aquatic life), Agricultural, Industrial, Navigation, Wild River, Scenic River, and Urban Stream. On a continuum of water quality, Drinking Water would rank highest followed by Recreational Water and Fishing Water.

TABLE 11

WATER ALLOCATIONS FOR THE CHATTAHOOCHEE RIVER
(CUBIC FEET PER SECOND)

	Present	Interim (to 1980)	Average Use Short-Term (to 1990)	Preliminary Peak Demand (to 2000)
Intakes:				
Gwinnett	17	17	12	18
DeKalb	124	178	152	280
Cobb	39	76	67	175
Atlanta	164	213	282	527
Unallocated		22		
Total Water Supply	344	506	513	1,000
Minimum Water Quality Flow	+750	+750	+750	+750
Minimum River Flow	1,094	1,256	1,263	1,750

Source: U.S. Army Corps of Engineers, Appendix B, Volume 2 (1978).

The Chattahoochee River is classified as Recreational/Drinking Water from its headwaters to Peachtree Creek. Between Buford Dam and Peachtree Creek, its quality is listed as good to excellent. From Peachtree Creek to Cedar Creek, the Chattahoochee River is classified as Fishing, and its quality is described as polluted (ARC, October, 1978).

Water quality data has been collected on the Chattahoochee River since 1968. Agencies involved in the collection of water quality data include the Atlanta Water Works, the U.S. Army Corps of Engineers, the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the U.S. Geologic Survey.

Water Treatment and Distribution

There are six primary water producers in the Atlanta region: City of Atlanta, Cobb County, DeKalb County, Gwinnett County, Clayton County, and East Point. Due to the scope of this study only the DeKalb County and City of Atlanta facilities will be described.

DeKalb County

DeKalb County maintains the Scott Candler Treatment Plant which draws water from the Chattahoocheee River to a maximum capacity of 80 mgd (124 cfs). Both incorporated and unincorporated areas of the county are served with the exception of that part of DeKalb County which is within the Atlanta city limits. DeKalb's system is the second largest in the region. During times of peak demand, the system is operating at or near capacity. It serves almost 200,000 customers within the county boundaries and wholesales water to the Conyers water system which serves Rockdale County. Retail rates utilize a declining block design and range from $1.17 to $0.48 per 100 c.f. inside the county; wholesale rates are $0.46 per 100 c.f.

From its source at the Chattahoochee River, the water is pumped two miles through Fulton County to DeKalb County. The rapidly growing southern reaches of the county are of concern to the water suppliers. The county has emergency interconnections with Gwinnett County and is considering purchasing water from Gwinnett County to meet future needs.

The DeKalb County systems are managed by a single director under the county's Community Planning and Development Director and the DeKalb County Commission Chairman. It has the authority to expand and to implement study recommendations.

The City of Atlanta

The City of Atlanta is served by the Atlanta Water Department which operates two plants, the Hemphill Plant with a capacity of 90 mgd and the Chattahoochee Plant with a 60 mgd capacity. As in DeKalb County, the system operates at or near capacity during peak periods. The City of Atlanta is served as well as various other towns within and outside of Fulton County.

The Atlanta system is the largest in the region serving almost 800,000 customers. The city obtains water from two intakes, both on the Chattahoochee River. There are no major interconnections with other water systems. The rate structure is uniform over the range of typical residential use with a charge of approximately $1.17 per 100 c.f. (inside the city). Lower rates apply to larger users. Sewer charges are $0.83 per 100 c.f. (inside the city). Water is wholesaled for $0.46 per 100 c.f.

Four major pumping stations supply the distribution system of the city: the Chattahoochee, Hemphill, Northside and Adamsville pumping stations. The latter three pumping stations comprise the Hemphill System which includes approximately 1,700 miles of distribution mains.

The Atlanta water system is managed by division directors operating under the city's Chief Administrative Officer. Major planning and management decisions must be approved by the mayor and council.

Both the DeKalb and Atlanta systems are adequate for present water supply needs. Both systems will require expansions, modifications, and/or additions in the comparatively near future. Various plans are under study by both agencies in order that they may keep abreast of the increasing water supply requirements of the region (U.S. Army Corps of Engineers, Appendix A, 1978).

Wastewater

A total of 96 municipally owned wastewater treatment facilities are included in the seven-county region. The R. M. Clayton facility, serving the City of Atlanta, is the largest having a secondary treatment capacity of 120 mgd (187 cfs). In addition there are three smaller municipal facilities, 23 industrial wastewater treatment facilities and 69 facilities operated by schools, hospitals, and other organizations.

The U.S. Army Corps reports (Appendix B, Vol. 1, 1978) that "County sewerage systems are relatively new since most development in the region has been relatively scattered and extensive countywide collection and treatment systems could not be justified. Most of the region contains numerous small package plants which service individual or joint subdivisions, apartment complexes, or commercial developments. Many are neglected or poorly operated, and an increasing number have been turned over to the counties for operation and maintenance." Septic tanks are used in areas that are not served by public systems. Most of the counties anticipate the consolidation of the smaller package plants and septic tanks into larger collection systems in the future.

Approximately 50 mgd (77 cfs) of wastewater is discharged into the Yellow, South, and Flint river basins. The Chattahoochee receives approximately 13 mgd (20 cfs) of treated wastewater which originates as water supply from Lake Allatoona.

A total of 183 mgd (283 cfs) of treated wastewater is discharged into the Chattahoochee below Peachtree Creek. This is the combined

capacity of five wastewater treatment facilities, and proposals are being considered that would increase this discharge to 265 mgd (410 cfs) (U.S. Army Corps of Engineers, Appendix B, Vol. 1, 1978).

DeKalb County discharges its treated wastewater into the South River Basin. Efforts are underway within the county to return some of this flow to the Chattahoochee River thereby reducing interbasin transfers.

Water Use Characteristics

Table 12 exhibits projected water use for the Atlanta region in the year 2000. The ARC based its most recent projections of water use and wastewater generation on the projected water use rates found in Table 13 (U.S. Water Resources Council, 1968). In general the projected total population in each category was multiplied by the appropriate water use factor with minor variations occurring depending on the category. The water use rates shown for the manufacturing/industrial sector were not used, however. Because the Atlanta Region does not contain large water using industries, the ARC did not deem the Water Resources Council's figures (1968) appropriate for Atlanta projections. Instead, industrial water use projections were calculated by multiplying the acres of intensive industrial land by 2,000 gallons per acre per day (ARC, March, 1979).

Seasonal variation in water use is listed in Table 14. Figures 9 and 10 display projections to the year 2000, as well as possible system adjustments made to meet the water supply needs.

Water Conservation

In 1977 the ARC adopted a water conservation policy that recommended modifications in local plumbing codes to require the installation of water saving appliances in new buildings. Legislation was enacted by the Georgia General Assembly in 1978 that required water saving toilets (3.5 gpm) and showerheads (3.5 gpm) to be installed and used as replacements after 1980 (Appendix F). Prior to this legislation, DeKalb County had enacted a water conservation ordinance which required new construction to have water conservation devices installed. The ordinance also stated that new carwash facilities be equipped with approved water recycling systems (Appendix G).

The results from the DeKalb ordinance have shown no decrease in water usage as yet. Indeed the Director of the DeKalb County Water and Sewer Department reported that after one year water usage was up 14 percent. This percentage increase was found by comparing the January usage prior to the ordinance with the January usage during the ordinance. The Director suggests that the increased usage may be attributable to a very cold winter since taps were left open to prevent pipes from freezing. The spring to summer usage showed a reduction of five percent from the previous year.

The ARC has also adopted several water management policy recommendations which cover emergency procedures, water system interconnections, and requirements for offstream storage. It recommends the

TABLE 12

ATLANTA REGION WATER USE PROJECTIONS
(MILLION GALLONS PER DAY)

	Average Use 1975	Average Use 2000		Maximum Day Use[1] 2000	
		Initial	Alt E	Initial	Alt E
Atlanta	86.8	116.4	116.4	175	175
Fulton	21.1	67.3	67.3	101	101
DeKalb	59.0	108.7	110.8	163	166
Cobb	29.7	76.0	74.1	114	111
Clayton	15.6	31.3	40.6	47	61
Gwinnett	14.5	53.7	50.7	81	76
Rockdale	3.2	16.0	13.4	24	20
Douglas	4.3	21.3	17.7	32	27
Henry (part)	1.0	6.0	4.8	9	7
Total	235.2	496.7	495.8	746	744

[1]Maximum day use is estimated to be 150 percent of average day use.

Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

TABLE 13

PROJECTED WATER USE RATES
(GALLONS PER CAPITA PER DAY)

Year	Domestic	Government	Commercial	Manufacturing and Industrial	Total
1970	74	20	28	37	159
1980	77	18	28	40	163
1990	79	17	28	41.5	165.5
2000	81	16	28	43	168

Source: U.S. Water Resources Council (1968).

TABLE 14

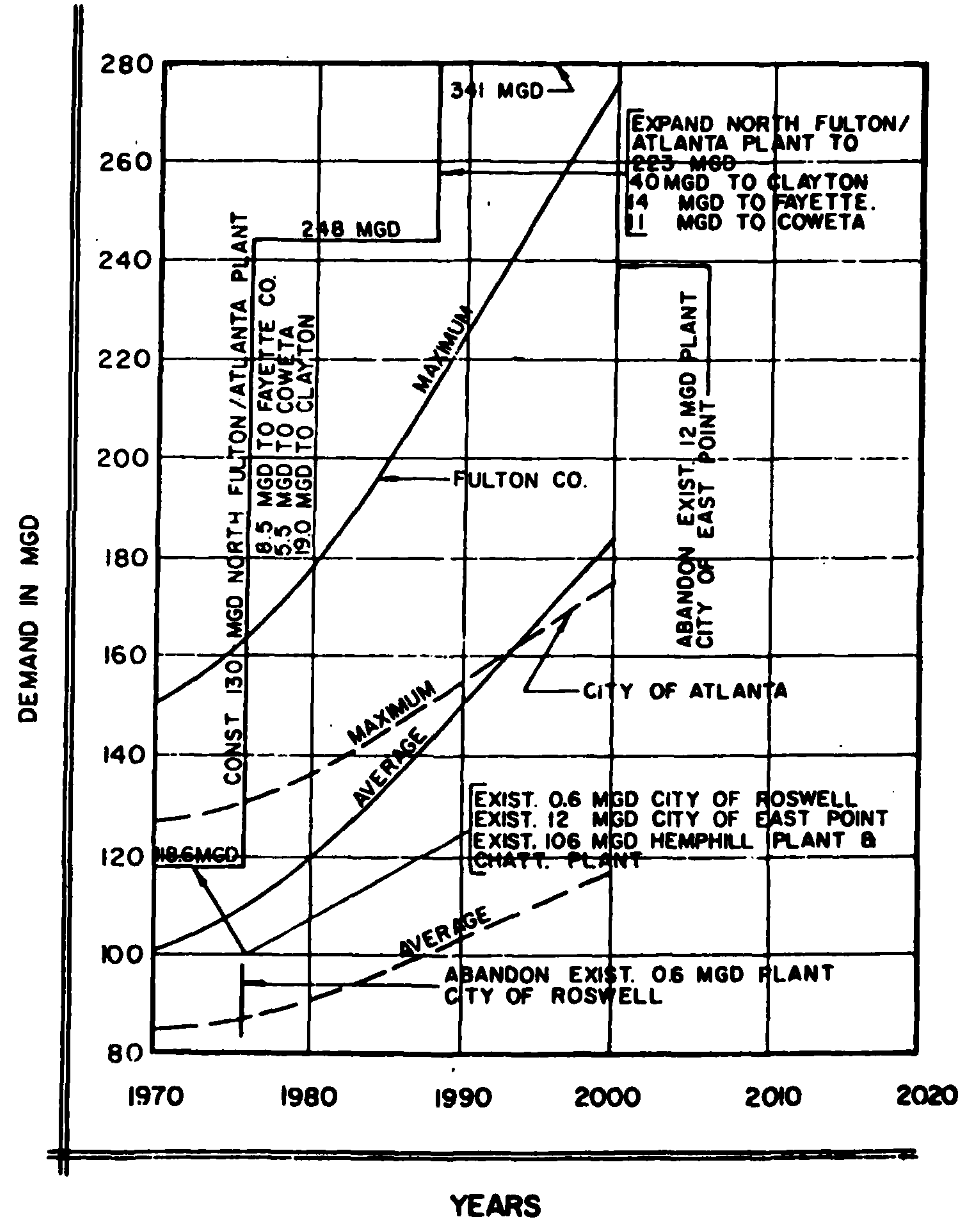
SEASONAL VARIATION IN WATER USE:
METROPOLITAN ATLANTA AREA

Month	Annual Average (PERCENT)	Month	Annual Average (PERCENT)
January	93	July	114
February	93	August	114
March	93	September	103
April	98	October	98
May	103	November	93
June	108	December	93

Source: U.S. Army Corps of Engineers, Appendix B, Vol. 3 (1978).

FIGURE 9

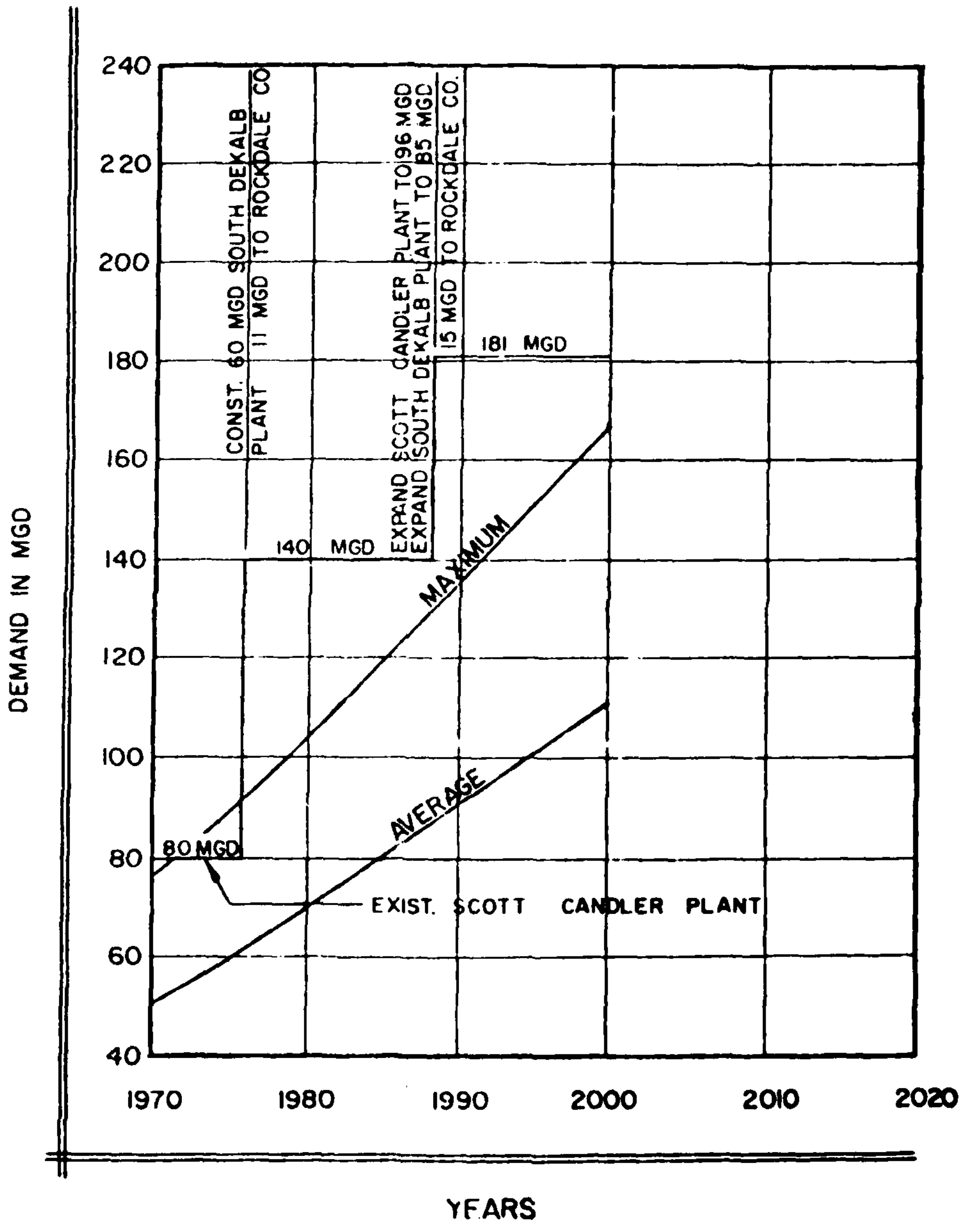
WATER USE PROJECTIONS: FULTON COUNTY



Source: U.S. Army Corps of Engineers, Appendix B, Vol. 3 (1978).

FIGURE 10

WATER USE PROJECTIONS: DEKALB COUNTY



Source: U.S. Army Corps of Engineers, Appendix B, Vol. 3 (1978).

use of plumbing codes, new pricing policies, and standards for water closets, urinals, showerheads, and faucets. It also specifies a range of applicable water pressures.

As a result of these recommendations the Corps revised its projected water use figures to reflect the new plumbing requirements. These adjustments can be found in Table 15. The Corps projects a possible savings of 13 percent by the year 2000 based on plumbing code changes (U.S. Army Corps of Engineers, Appendix B, Vol. 2, 1978). Figure 11 displays the effects of the water conservation program and the projections to the year 2000 and beyond.

Wastewater resue is also under consideration as a conservation measure. Many firms and institutions with treatment facilities are already reusing effluent where this has seemed cost-effective compared with water rates. Clearly, many forms of reuse are infeasible, but it remains to be determined just how much reuse might take place.

Atlanta has operated a leak detection program since 1950. Every year, 200 miles of water mains are surveyed for leaks so the whole system is covered every 10 years. In its first 25 years, this program discovered and repaired leaks totaling 12.35 mgd, so that it has been highly successful. In the last 10 years, the cost of fixing these leaks has been approximately $0.02 per 1,000 gallons saved.

SUMMARY OF CURRENT AND FUTURE PROBLEMS

The Atlanta region, despite its humid southeastern U.S. location with 48 inches of rain a year, is confronted with some serious water supply and water quality problems. As outlined previously, the region faces a rapidly growing population and at present commands a limited supply of water. The limitation is both political and physical.

The U.S. Army Corps of Engineers (Appendix B, Vol. 2, 1978) states that "The water available for water supply in the Chattahoochee River is severely limited by the present operation of the total Chattahoochee-Lanier system. Present water supply withdrawals and flow required for water quality almost exactly total the present minimum flow in the river from Buford Dam to Atlanta." In order to meet projected water supply needs from Lake Lanier, alterations in the system must be made and these would create legal problems in terms of the congressionally approved purposes of Buford Dam, public sentiment relating to recreational facilities affected, power supplied, and changes in water supply facilities, and economic ramifications in terms of rate changes, pricing arrangements, and incurred costs.

Water quality in the Atlanta region ranges from excellent to polluted. National standards as set forth in Public Law 92-500 are resulting in increased costs of wastewater management facilities and treatment. Continued growth and development in the area will involve further expenditures.

TABLE 15

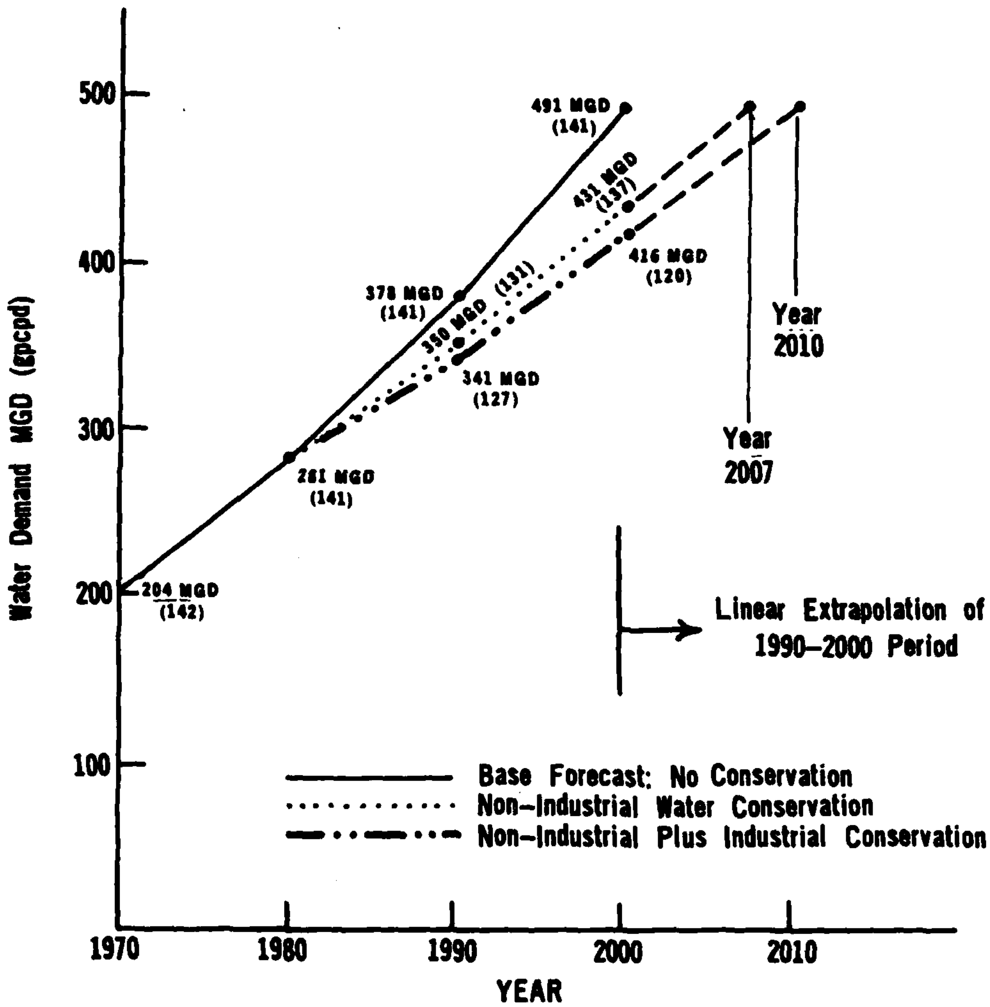
EFFECTS OF PLUMBING CODE ALTERATION ON WATER USE

Year	Population (MILLION)	Conservation Measures	Average Day Use Residential	Commercial	Industrial (MGD)	Public/ Unaccounted	Total	Percent Saved
1975	1.72	None	130	48	34	33	253	0
2000	3.47	None	281	97	69	56	503	0
	3.47	Plumbing Codes	233	86	49	69	437	13

Source: U.S. Army Corps of Engineers, Appendix B, Vol. 2 (1978).

FIGURE 11

WATER DEMAND FORECASTS: ATLANTA REGION



Source: Atlanta Regional Commission (March, 1979).

The enactment of water conservation policies in the Atlanta region has been so recent that it is not yet possible to assess effects on water usage. Water and wastewater price changes also serve to confound the issues making it all the more difficult to attribute water savings to one policy or another.

CHAPTER IV

MEASURE-SPECIFIC ANALYSIS

This section identifies water conservation measures that are applicable to the Atlanta metropolitan area and describes measure-specific analysis of those measures. This consists of such determinations as technical feasibility, social acceptability, and implementation conditions. The effectiveness of each measure in reducing future water use is estimated and the costs of implementation, as well as any other disadvantageous or advantageous effects of implementation, are estimated. The results of these determinations form the basis for the evaluation to follow, which incorporates the characteristics of present and future water supply systems.

APPLICABILITY

The applicable water conservation measures for the City of Atlanta are those measures that address water users now occurring or expected to occur within the region. Measures already implemented in Atlanta, or which are expected to be implemented in the absence of the Federal plan, are not considered applicable. Since every study area maintains some unique characteristics whether they be social or physical, the background and descriptions of the City of Atlanta have been examined to provide a basis for selecting applicable water conservation measures. The measures considered, and those found applicable, are shown as Table 16, in columns 1 and 2, respectively.

Regulation

Specific Federal laws and policies are not applicable in Atlanta as they set standards or procedures whose enforcement or application is not a matter of local option. Many compliance-related actions may not involve actual water conservation measures but instead utilize supply augmentation techniques or more stringent water quality controls. The Georgia legislature in 1978 enacted a bill specifying a new water conservation-oriented plumbing code for new structures (this code is now scheduled to take effect July 1, 1980). Therefore, this measure is non-applicable for future consideration.

Management

The only management measures not considered applicable in Atlanta are leak detection and metering. The Bureau of Water has an active leak detection program which, on investigation, appears comprehensive and effective. The water distribution system is 100 percent metered at the present time.

TABLE 16

POTENTIAL WATER CONSERVATION MEASURES: ATLANTA

Water Conservation Measures	Applicable	Technically Feasible	Socially Acceptable
REGULATION			
LONG-TERM			
Federal & State Laws & Policies			
A. Presidential policy	no		
B. PL 92-500	no		
C. 1977 Amendments (Clean Water Act)	no		
D. Safe Drinking Water Act	no		
Local Codes & Ordinances			
A. Plumbing codes for new structures	no[1]		
B. Plumbing codes--retrofitting	yes	F	P
C. Sprinkling ordinances	yes	F	P
D. Changes in landscape design	yes		
E. Water recycling	yes	P	F
Restrictions			
A. Rationing			
1. Fixed allocation	yes	F	P
2. Variable percentage plan	yes	F	P
3. Per capita use	yes	F	P
4. Prior use basis	yes	F	P
B. Restrictions on specific uses			
1. Recreational uses	yes	F	P
2. Commercial & institutional uses	yes	F	P
3. Car washing	yes	F	P
CONTINGENT			
Local Codes & Ordinances			
A. Sprinkling ordinances	yes	F	F
B. Water recycling	yes	P	F
Restrictions			
A. Rationing			
1. Fixed allocation	yes	F	F
2. Variable percentage plan	yes	F	F
3. Per capita use	yes	F	F
4. Prior use basis	yes	F	F
B. Restrictions on specific uses			
1. Recreational uses	yes	F	F
2. Commercial/industrial uses	yes	F	F
3. Car washing	yes	F	F

TABLE 16 (Continued)

POTENTIAL WATER CONSERVATION MEASURES: ATLANTA

Water Conservation Measures	Applica-ble	Technically Feasible	Socially Acceptable
MANAGEMENT			
LONG-TERM			
Leak Detection	no[1]		
Rate Making Policies			
A. Metering	no[1]		
B. Rate design			
1. Marginal cost pricing	yes	F[2]	F
2. Increasing block rates	yes	F	P
3. Peak load pricing	yes	F	P
4. Seasonal pricing	yes	F	P
5. Summer surcharge	yes	F	P
6. Excess use charge	yes	F	P
Tax Incentives & Subsidies	yes	F	F
CONTINGENT			
Rate Making Policies			
A. Rate design			
1. Marginal cost pricing	yes	F	F
2. Increasing block rates	yes	F	F
3. Peak load pricing	yes	F	F
4. Seasonal pricing	yes	F	F
5. Summer surcharge	yes	F	F
6. Excess use charge	yes	F	F
EDUCATION			
LONG-TERM			
Direct Mail	yes	F	F
News Media	yes	F	F
Personal Contact	yes	F	F
Special Events	yes	F	F

TABLE 16 (Continued)

POTENTIAL WATER CONSERVATION MEASURES: ATLANTA

Water Conservation Measures	Applica-cable	Technically Feasible	Socially Acceptable
CONTINGENT			
Direct Mail	yes	F	F
News Media	yes	F	F
Personal Contact	yes	F	F
Special Events	yes	F	F

yes--applicable to conditions presently existing, or expected to exist in Atlanta
no--not applicable to Atlanta conditions
F--feasible or acceptable under present conditions, or conditions expected to exist in Atlanta
P--potentially feasible or acceptable; feasible or acceptable only if conditions change in specific ways.

[1]Measures already implemented in Atlanta.
[2]Further analysis showed that implementation of this measure would increase water use, thus rendering marginal cost pricing infeasible as a conservation measure.

Education

All educational measures are considered applicable in Atlanta.

TECHNICAL FEASIBILITY

Measures are considered technically feasible if, when implemented, they actually bring about some measurable reduction in water use. In other words, their effectiveness must be greater than zero. Occasionally

it will be necessary to perform a detailed effectiveness calculation in order to determine whether water use will be reduced, but some measures can be eliminated immediately as clearly non-effective. These measures are classified as technically infeasible. Table 16, column 3, shows the determinations made for measures previously found applicable for Atlanta.

Regulation

Of the various applicable regulatory measures, change in landscape design was fou infeasible, and water recycling potentially feasible. In the case of the first measure, Atlanta's humid climate seems to rule out the possibility of devising generally applicable landscape designs which would significantly reduce sprinkling water requirements. This results from lack of availability of sufficient numbers of drought-resistent species of trees, shrubs, and grass, which are also tolerant of humid conditions. Water recycling is not included as feasible in the absence of specific proposals for recycling applications which would conserve water. Should such applications be identified, this measure can be changed from potentially feasible to feasible.

Management

All applicable management measures are considered technically feasible, pending further investigation.

Education

All applicable educational measures are considered technically feasible, pending further investigation.

SOCIAL ACCEPTABILITY

The purpose of a study on the social acceptability of water conservation measures is, by definition, the determination of whether certain measures are or are not socially acceptable, that is, acceptable to the community in which they are proposed. But unlike the determination of technical or even economic feasibility, such clearcut decisions are rarely (if ever) attainable in the area of community acceptance. Both the number and complexity of factors involved preclude the prediction of community response with certainty. The goal, then, of such efforts is a more modest one: to increase the quality of the judgments made as to the probable response a community will make to a proposed measure.

Community response to a conservation measure is, in important part, a function of its congruence with the community's dominant social ideologies. The question is: Is a specific measure perceived as being harmonious with those core values, beliefs, attitudes and feelings that define a community's commitments, or is it seen as in some way violating them? In so far as progress is made in answering that question, one's judgment as to the social acceptability of the measure improves.

It is clear, then, that to serve the ultimate purpose of making such judgments, it is necessary first to achieve some understanding of those ideological themes in a community that are of relevance to conservation. Thus, the immediate goal of a study to determine the social acceptability of conservation measures is the identification and delineation of those community values, beliefs, attitudes, and feelings that will influence response to any and all measures.

The study procedures (sampling and methods) used to gain an understanding of the social ideologies that characterize Atlanta are detailed in the introduction to this report. However, because a study of social acceptability involves goals and methods that depart from traditional U.S. Army Corps of Engineers interests and expertise, it may be useful to review several issues before the discussion of Atlanta begins.

The studies of social acceptability reported here used personal interviews with persons perceived by citizen advisors as exercising considerable influence in the community, and mail questionnaires directed to a representative sample of the general public. In both cases several kinds of issues were discussed. The relevance of obtaining the evaluations of respondents to specific conservation measures that might be proposed in the future is self-evident. An example would be plumbing codes that specify low-flow appliances. But what might be less immediately understood is the rationale for raising matters in these discussions that, at best, may be seen as only tangentially related to water conservation, and, at worst, would appear to be totally unrelated. Examples of such issues are water rights, alternatives for increasing water supply, or the question of inhibiting or fostering urban growth.

Indeed, such issues do not constitute conservation measures. The discussion of them is, rather, a means to an end. For it is by way of their consideration of such issues, often somewhat controversial, that respondents reveal those values, beliefs, attitudes, and feelings that characterize their social ideologies. Thus, although the restriction of urban growth may not be a possible conservation measure (and certainly not one on which the U.S. Army Corps of Engineers would take a position), discussion of it may well produce the clearest picture of those values and principles of judgment that the community uses in its evaluation of any and all conservation measures. In other words, discussion of such issues is often, indeed usually, more successful in leading to the identification and delineation of basic values than is the discussion of specific and circumscribed conservation measures.

It must be reemphasized that the immediate goal of a study on the social acceptability of conservation measures is to understand the community, to put a finger on its pulse, to understand the various forces at work within it, to know who holds what values and why. For it is only such an understanding-in-depth that can serve as an enduring base for judging community response to any specific measure.

This report presents two versions of the analysis of the social acceptability data. The one presented here, in the body of the text, is appropriate to the style of the report as a whole--it presents the

substance of the findings in a condensed and concise form and uses an objective tone. A considerably more detailed analysis of both the interview data and the survey questionnaire data is presented in Appendix D; there, especially, an attempt is made to preserve the original character of the interviews in which the respondent often presented his position in an unrestrained and emotional manner, for in understanding social ideologies the strength and quality of the effect that is associated with a position is as important as the substantive aspect of the position itself. It need hardly be added that the views expressed in the data, as well as the passions with which they are held, are totally disassociated from the U.S. Army Corps of Engineers itself.

Personal Interview Analysis

General Issues

Analysis of the interview data revealed four issues that permeated the discussions of this special group of respondents. These issues are most important in characterizing those fundamental attitudes, values, and concerns that are of relevance to conservation.

Urban Growth: Respondents divided themselves into two groups with respect to how they viewed the phenomenon of urban growth. There were those who conceived of such growth as a "natural force," beyond the control of man, and saw its course, its advance or decline, as inevitable. On the other hand, there were those who perceived urban growth as determined by man's actions. However, many in this latter group felt that while such growth was thus *logically controllable, it* would never actually be controlled because (1) to do so would violate American cannons of freedom and (2) both "those in power" and the general public would be against it because they are not convinced it benefits them.

Thus, although for different reasons, both groups of respondents agreed that the urban growth of Atlanta would continue. Further, both groups of respondents agreed that, on balance, the benefits of continued growth outweigh the costs.

The groups split again, however, on the important issue of who it is that benefits and who it is that pays for urban growth. Those respondents who saw growth as natural tended to be those who saw its benefits and costs to be fairly and impersonally distributed, according to the economic principle of reward for effort. Those respondents who saw growth as man-made tended to be those who saw the benefits and costs of growth to be inequitably or unjustly distributed, with the benefits disproportionately given to the "haves," and the costs disproportionately borne by the "have-nots." In general, the "have-nots" were defined in terms of both specific groups of disadvantaged and the majority of the unorganized public.

This brief review of the discussion of urban growth reveals a basic dichotomy of values that runs through the Atlanta sample; various groups of influence align themselves on one side or the other. How and where the benefits and costs associated with a given conservation measure are

distributed, then, is an important factor in assessing its social acceptability, for any measure encounters the value differences that distinguish these groups and determine their support or opposition.

Racial Antagonism: Although no questions were asked concerning race, respondents frequently raised the matter of racial tension in the context of other concerns; they clearly considered it relevant to their discussions of environmental issues. In brief, it was pointed out that the political and economic powers of Atlanta, once fused, were not separate. Respondents felt that new alignments characterized the city--black/political and white/economic. They were seen to be in frequent conflict, with different loyalties, different goals, different agendas, and most importantly, different attitudes toward the proper role of government. The respondents believe that black political forces see government as properly interacting with economic affairs to ensure a more equitable distribution of benefits and costs for what they see as their people--disadvantaged blacks. And they believe that white economic forces see government as properly following a strict hands-off policy, permitting the market to operate freely. Any water conservation measure, then, that is perceived as entering the realm of benefits and costs to particular groups, of government regulation versus unrestricted market, also may be perceived as entering into the area of possible racial tension.

Mutual Distrust: Respondents representing their own groups revealed noteworthy distrust of "other" opposing groups. That is, it was clear from the content and tone of the interviews that respondents not only saw groups with different attitudes or values as being substantive disagreement, they also doubted the virtue of their motives. Different stances on environmental issues were often personalized and transformed into negative emotional assessments of those holding the opposing position.

Mutual Ignorance: Despite numerous briefings of the Citizens Task Force of the U.S. Army Corps of Engineers' Atlanta Urban Study over the past five years, the interview respondents, although generally spokesmen for environmentally enlightened and concerned groups, displayed noteworthy ignorance or misunderstanding of the positions held by opposition groups. Perhaps the emotional commitment to a given stance interferes with understanding and remembering opposing arguments.

Specific Conservation Measures

In addition to the general ideological issues just discussed, the interviews measured response to five specific conservation measures.

Pricing: Respondents were of two minds on the effectiveness of using price increases as a residential conservation measure: Some felt that any reasonable increase in the price of water would effect little if any conservation because water was a necessity and people would have to use it regardless of what it cost. Others, who assume that residential users use more than is absolutely necessary, thought that indeed increased prices would result in a significant reduction in the amount of water used...if the price increase were severe.

Concern was expressed that the level of price increase necessary for it to prove effective, would, at the same time, affect most drastically those who could least afford it, those with large families and small incomes, whose margin for potential reduction is, by definition, narrower. Some respondents, then, felt that pricing was a conservation measure the costs of which would be inequitably distributed on the poor. Some went even further and felt it might become a racial issue on the logic that blacks made up a disproportionate share of the poor.

Regarding business and industrial use, there was considerable agreement that pricing would not be effective in reducing water demand. This conclusion was based on the argument that free enterprise, in its pursuit of profit, always strives to minimize costs and therefore had already reduced water use to the lowest level possible--that amount needed for production of goods and services. They argued, then, that price increases would have the undesirable effect of raising consumer costs or of causing business to move or to fail.

Renovated Wastewater: Respondents representing all groups approved the idea of renovating wastewater; they agreed, however, that it was not, in their opinion, economical in the Atlanta area.

Lawn Watering: Except in water supply crises, respondents were agreed that reduction in lawn watering would be perceived by the public as incongruent with their perception of the Atlanta climate and thus as unreasonable restriction of personal choice. Consequently, mandatory restrictions would be resisted and costly if not impossible to enforce.

Plumbing Codes: The respondents were in agreement in their approval of the mandatory installation of flow-reducing plumbing appliances in new construction. Such codes are a rare example of a legally structured conservation measure which is perceived as a legitimate "interference" with the market. It is so because it is seen as being without costs; that is, manufacturers can switch over to the production of such appliances, retailers can sell them, builders can use them, and consumers can use them, all without extra cost.

Education: Only a few respondents are genuinely sanguine about the possibilities of changing adult habits of water use through education. Most respondents are pessimistic about obtaining behavior change through education alone and place more confidence in measures that appeal to self-interest. Many respondents felt that to be effective one must educate the individual at a young age, and socialize the individual into a different view of the relationship between man and environment.

Questionnaire Analysis

In order to identify the general public's acceptance of a range of water conservation measures, a questionnaire was formulated and mailed to 750 residents selected randomly from the telephone directory. In addition, questionnaires were mailed to 200 individuals who, in the past, had expressed interest in the U.S. Army Corps of Engineers activities. Among the former group, 22 percent completed and returned the questionnaire, but the return rate increased to 34 percent among the

sample of 200.

Before analyzing responses to the questionnaire, it should be noted that these two groups are nearly the same in their attitudes toward water conservation. While the special interest group was more knowledgeable than the general public on all but one water conservation measure (lawn watering), there were no differences between the groups in attitudes toward any of the conservation measures (see Appendix D).

In general, the response of the general public to water conservation is extremely positive--over 90 percent expressed favorable attitudes to the measures presented. As discussed in Appendix D, such a favorable response may be in part a function of the high socio-economic background of the respondents. In general, women actively favor water conservation by a 2 to 1 margin over men; the older one is, the less likely one is to exhibit a favorable attitude to water conservation; the amount of formal education is not statistically related to favorable individual views on water conservation (see Appendix D).

More specifically, the most acceptable water conservation measures are building codes that require low-flow plumbing devices and the reuse of wastewater for irrigation and industry. Of the eight conservation measures evaluated, the least preferred measures are pricing and the control of urban growth (Table 17).

Analysis of the additional four questions for each of the eight water conservation measures demonstrates the lack of correspondence between how much a person knows about a measure and how highly he or she ranks that measure overall. This finding raises serious doubts about the potential effectiveness of an educational campaign to persuade the public of the value of a technically feasible measure.

The most important factor affecting an individual's overall evaluation is its perceived effectiveness--the individual's perception of how much water the specific measure might save. The implication of this finding requires additional research (Appendix D): If perceived effectiveness determines an individual's overall evaluation of a measure, then educational campaigns would emphasize potential savings of gallons and dollars; but if perceived effectiveness is the result of a person's overall evaluation, an educational campaign would emphasize the collateral qualities of each measure such as convenience and equity.

In the context of these general findings, two specific water conservation measures selected as exampled may be examined in detail--pricing and lawn watering. Over half of the sample knows little or nothing about pricing as a means of conserving water; however, despite the lack of knowledge, pricing as a conservation measure is still familiar to more of the public than are five of the other seven measures presented. And, while more than half of the respondents perceive price as effective in saving water, and as economical, they feel that water-conserving pricing should be implemented only when the need is at least moderately serious (see Appendix D). Such responses to pricing appear pervasive--there are no age, sex, or educational differences in attitudes on any questions regarding price.

TABLE 17

WATER CONSERVATION MEASURES RANK ORDERED ACCORDING TO OVERALL EVALUATION: ATLANTA

1. Building codes require water-conserving fixtures
2. Sewage reuse for irrigation and industry
3. Educational campaigns
4. Individual installation of water-conserving fixtures
5. Government intervention during drought
6. Lawn-watering reduced
7. Pricing
8. Control of urban growth

A similar pattern is observed in the public response to lawn watering only to a stronger degree. While they perceive it as effective and economical, they feel that the need for water must be moderately serious before a reduction of lawn watering should occur. One difference from princing is that the willingness to implement reduction in lawn watering decreases significantly with age (Appendix D).

Implications of Results

Perhaps it should be reemphasized here that the goal of a study of the social acceptability of water conservation measures is something short of predicting community response with certainty. Rather, such inquiries must be satisfied with probabilities and a study should be considered successful it it raises the confidence placed in such judgments of probably community acceptance or rejection. The purpose, then, of a social acceptability study is to inform the U.S. Army Corps of Engineers of community values, attitudes, beliefs, and feelings so that its policies and programs may be based upon such social realities just as they rest upon the realities of technology and economics.

How is the understanding of the community to be used? The process involved can perhaps best be described by a series of questions:

1. How does the conservation measure being considered fit with what have been identified as central ideologies of the community?

2. What special interest groups can be expected to support it?

3. And who will oppose it?

4. What are the relative strengths of these groups?

5. How will the public respond to it?

6. Are there ways of presenting the measure or of redefining it or modifying it so that it would be perceived as not only in line with, but as promoting a community value?

Of course, such analytical conversations are long and detailed and, logically, each and every possible conservation measure could be so examined. However, we are here interested only in illustrating the process and a consideration of two specific conservation measures will suffice.

Pricing

A review of the interview responses specific to increased pricing as a conservation measure emphasizes several points:

1. Increasing block rates must be considered separately for residential and business use as different issues are involved;

2. Everyone agreed on its potential effectiveness for reducing residential demand;

3. The strongest objection raised to application of the measure to residential water use was that it would bear hardest on those with large families and, therefore, on the poor and the black; and

4. Two objections were raised to using the measure in business and industry as distinct from residential use; the position was taken that there was no margin of waste on which it could work its effect, and second, it was perceived as constituting an unfair shift in the "rules of the game," that is, in the anticipated costs of production.

These points emerged from an analysis of responses to direct questions on pricing as a conservation measure, and they are of commensurately direct relevance. But their meaning expands and their importance grows when connected to the broader ideological issues revealed by the respondents in their discussion of urban growth.

For example, from this we learned that one major ideological

position appearing in Atlanta was the belief that the benefits and costs of growth are inequitably distributed; if left to itself, if uninterfered with, growth tends to benefit the rich and cost the poor. Respondents holding such a position felt that government should intervene to counter such inequities with programs, such as the progressive income tax, that work on an opposite principle, namely, to place the greater economic burden on those who can afford to pay it.

Thus, the objection to increasing block rates as possibly placing a disproportionate burden on the poor is not an isolated one; it is, rather, a manifestation of a general ethic, of a deeply felt commitment to a specific definition of fairness--fairness defined as equity.

Further, although there are many groups that would hold these values, perhaps the one of most current importance would be the leaders of the black community; leaders who, at the same time, head the city government.

It would appear, then, that the prospects of the use of substantial increasing block rates as a measure to effect conservation would be greatly enhanced if the proposal could somehow avoid the charge of placing an added burden on those least able to bear it. If not, considerable general opposition could be easily mobilized, for the ideological base of the objection is widespread and, perhaps of even greater immediate consequence, most probably the powers of local government could be easily mobilized against the proposal.

How this might be done is a challenging question and certainly beyond the scope of this report. But the point here is the warning, the awareness of the need to confront and handle an ideological consequence of pricing if the measure is to enjoy a high probability of being socially acceptable.

Data from the questionnaire raise a further possible constraint on the use of increasing rates as a conservation measure: It is not popular with the general public of Atlanta--ranking 7th out of 8 measures in overall acceptability. They see it as neither effective nor economical, except under conditions of drought. Almost certainly these assessments result from a conviction that the current level of water use is a necessity; the argument would run that no matter what the price, people would have to use as much water as they do now, hence, no saving either of water or of money. Interestingly, this is the same logic that the community influentials applied to pricing in business and industry, namely, that there exists no margin of waste on which pricing could operate. This belief then constitutes an additional challenge to the use of pricing as a conservation measure. Again, awareness of it presents the opportunity to deal with it.

The question of the use of increasing block rates in business and industry is related to a different set of ideological concerns. The judgment, or more accurately, the belief held by most respondents that business and industry do not waste water is neither an isolated assessment nor is it one based on evidence or experience. It is, rather, essentially a deduction which follows from the general placement of trust

in the economic rationality of free enterprise, of trust in the principle of maximizing profits by minimizing costs. The assumptions, then, are two: first, there is the assumption that such a "law" is, indeed, being applied, and, two, that its application will result in using only that amount of water that is necessary.

A corollary to that belief, to that confidence in the operation of an economic principle, is a policy of noninterference. Government (or, for that matter, public utilities which are often seen as quasi-governmental) ought to stay out of the picture and let the market operate unto itself.

These are powerful beliefs held by influential forces in Atlanta and are likely reinforced by the general public; efforts to implement the use of increasing rates as a conservation measure in business and industry should account for these sensitivities. Their support or opposition would depend heavily upon how the measure was seen--as an arbitrary and unwarranted intervention into the economic arena, or as itself a result of the operation of market forces. In the latter case, price increases, although perhaps unwelcome, would at least be "legitimate"--that is, in tune with a social ideology.

Plumbing Appliances

The use of low-flow toilets and shower heads as a water conservation measure is of special interest in Atlanta because it is on the brink of implementation there. Through the initiation and support of the Atlanta Regional Commission, the state legislation has enacted a law requiring the use of such plumbing appliances in new construction as of 1980. Rather than attempting to analyze the future, to anticipate possible response to the proposal of a conservation measure, it is here possible to attempt to analyze the past, to explain the response that led to its adoption; rather than the question, is it socially feasible, the question becomes why was it socially feasible.

Those interview respondents in Atlanta who were involved in the law's passage provide long and detailed explanation--from the gathering of data to back the argument of the measure's potential effectiveness to the political machinations in the state house. All of such history is undoubtedly relevant; however, the focus here is on how the measure fit into the main ideological currents that characterize the Atlanta community.

From that perspective, two questions immediately arise: (1) Why wasn't the law seen as lowering or "taking away" that amount of water defined as a necessity; and (2) why wasn't the law seen as a direct government intervention into the marketplace. The answer to the first is that the reduction in water use achieved by such appliances is assessed as being essentially unnoticeable; that is, although the user of the shower or toilet is intellectually aware that less water is being used, his senses do not distinguish the lowered levels; both plumbing devices will be experienced as they had been. The expectation, then, is that the quality of life, as far as water use is concerned, will be unchanged. Thus, the law does not constitute a threat to a standard of living made

sacred by habit.

Data from the survey support and expand this conclusion--of the eight conservation measures they reviewed, the public sample gave plumbing codes its highest overall evaluation. And this first-ranked status rests not only upon its being seen as effective (89 percent) and economical (82 percent), but also upon the fact that it is seen as generally acceptable, that is, only 9 percent of the sample required that a serious water shortage be a condition for its implementation.

The second question concerns the law as a possible incursion into free enterprise. To begin, although plumbing codes do act as constraints on business and industry, they are not perceived as interventions of the same order as pricing. To set price for the purpose of conservation is to directly tamper with the economic laws of the market, to set codes is merely to establish the conditions within which economic laws can continue their automatic operation.

The codes also avoid another pitfall--they do not hit the pocketbook of the construction industry. A low-flow fixture costs about the same as a standard fixture, and the labor costs to install either are identical. Thus, the switch-over is not at anybody's expense.

It should be noted that the one group that could have suffered economic harm--plumbing manufacturers and suppliers with large stocks of standard fixtures--were more than adequately represented in the legislature. The resolution was reasonable and easy: delay the date of mandatory implementation until inventories could be liquidated. Again, this manuever can be seen simply as a political expedient. Certainly, it was that; but at the same time it was more than that--it was an example of a condition that successfully moved the measure ideologically away from a conflict between business and government.

Of course, it is easier to determine the social feasibility of a conservation measure after its acceptance than before; ex post facto analysis tends to be convincing. But it should be realized that the attempt to explain the achieved fate of a conservation measure serves essentially the same purpose as attempting to predict what the fate of a measure will be, namely, practice in speculating on the degree of congruence between a prospective measure and the social ideologies that determine, in important part, its social acceptability.

Acceptability of Specific Measures

The application of this analysis of social acceptability is illustrated by the last column in Table 16. Of the 40 classes of measures found to be technically feasible or potentially feasible, 26 are shown as socially acceptable, and an additional 14 are given as potentially socially acceptable. Plumbing codes which would require retrofitting existing structures, even on a long-term, phased basis, are considered potentially feasible, as the community would require some evidence that this degree of interference with private property and private affairs was warranted.

Sprinkling ordinances, water use restrictions of all types, and rate structure innovations other than marginal cost rates are all classified as potentially acceptable for long-term implementation. In each case, it is reasoned that the community would regard the measure as an intrusion into matters of private prerogative, and clear and sufficient justification would need to be present. It must be widely evident that the common good will be served, and that individual inconven' .ce will be minimal. Marginal cost-based rates are excluded from this reasoning, reflecting the apparent readiness of the community to support rates which are strictly cost-based, provided they do not greatly rearrange the existing incidence of consumer costs and benefits (this would appear to be the case for marginal cost-based rates in Atlanta). All the foregoing measures are considered immediately acceptable as contingent measures, however, since the terms of their implementation would imply the existence of clear and sufficient justification.

IMPLEMENTATION CONDITIONS

Following determination of social acceptability, the required implementation conditions for the remaining water conservation measures must be determined. In some cases, this will require defining the measure more specifically, or subdividing a measure into several related or alternative measures. For example, information obtained in the course of the investigation of social acceptability reveals some broad parameters for acceptable types of rate redesign. New rates must not appear to discriminate among certain broad groupings in the community: low-income black vs. affluent white, or constituencies of political leaders vs. business and industrial interests. These insights facilitate the design of specific rate structures which minimize problems with public acceptance. Also, when a measure is seen as broadly acceptable, such as educational efforts, several alternate forms of the measure may be devised so as to more fully explore its potential.

In the present study, forty types of water conservation measures have been found socially acceptable or potentially acceptable. Some of these measures, such as educational efforts, are broadly defined, suggesting the possibility of analysis of an even larger number of individual measures. Due to time and resource constraints, only five specific measures have been selected for further analysis here. These include three alternative forms of an educational effort directed to voluntary conservation, augmented by distribution of bottle kits and shower head inserts, a contingent sprinkling restriction ordinance, and the adoption of marginal cost based rates. Implementation conditions for these measures are summarized in the following paragraphs.

Measure A1--Modest Kit Distribution

This water conservation measure consists of the distribution of plastic bottles for placement in toilet tanks, inserts for shower heads, and dye tablets for detecting toilet leaks. These devices would be installed on a voluntary basis by residents and would, if properly installed, reduce flushing volumes, reduce shower flows, and assist in

the correction of previously undetected leaks. The distribution of the kits would be effected by making them available at public places, and depending upon interested residents to pick them up. The kits would be distributed at no cost to the residents.

Residents would be encouraged to obtain and to install a kit by an educational campaign including continuation of the public service television announcements now produced by the Atlanta Regional Commission, augmented by annual bill inserts sent to all water users. Instructions for proper installation and maintenance would be included with each kit, and repeated on television announcements and in bill inserts. The kits would remain available, and the program would continue throughout the full planning period.

This conservation measure could be implemented by the Atlanta Water Bureau, alone or in conjunction with the Atlanta Regional Commission. Other interested agencies could assist or could implement the program themselves. Except for the bill insert, active participation by the Water Bureau is not essential. It is estimated that 15 percent of all residential units in Atlanta (0.15 * 223,000 = 33,450) would install the kits in the first year. Thereafter, kits would continue to be installed at a lower rate. It is estimated that the number of new kits installed in residential units will average 1,110 kits per year throughout the planning period, exclusive of the first year.

Measure A2--Moderate Kit Distribution

The Moderate Kit Distribution program would use the same kit previously described. However, instead of providing kits at a central location to be picked up by residents during the first year, kits would be distributed door to door by the responsible agency. As a result, more households are expected to install the kits. Specific installation rate assumptions are given in the section on effectiveness.

Measure A3--Maximum Device Distribution

The maximum effectiveness program for plumbing fixture modification would provide door to door distribution and installation (where permitted by owner) of the following kit:

1. Plastic toilet tank dam sets, as required

2. Flow reducing inserts for showers heads, or replacement shower heads, as required

3. Faucet aerators, as required.

It is assumed that 90 percent of residential households in Atlanta would either install or permit the installation of these devices.

This program would be expensive to implement, and would present various logistical problems, depending upon the attempted rate of implementation. it is assumed that the program would spread over a 10-year period from 1980-1989, with 10 percent of all households visited

each year. It is further assumed that a free reinspection service is provided, and that 2 percent of all households existing in 1980 are reinspected each year throughout the planning period.

Measure A4--Contingent Sprinkling Restrictions

If the City of Atlanta were to experience a critical water supply problem which necessitated the implementation of a contingent water conservation measure, the following water use restrictions might be adopted:

1. Adjust or control landscape watering systems to avoid runoff. Confine all watering and sprinkling to alternate days between midnight and noon with the exception of commercial florists and plant nurseries.

2. Discontinue operation of all ornamental fountains, waterfalls, reflecting ponds and similar amenities.

Informing the public of these restrictions when they become effective and explaining their application would be the responsibility of the Water Bureau. Enforcement would be carried out by Water Bureau inspectors, employing verbal and/or written warnings. Continued violation of the restrictions could result in disconnection of the water service for the duration of the emergency.

Measure A5--Change in Price Structure

A change in the structure of water and wastewater rates is another potential water conservation measure for Atlanta. The specific structure to be considered is one based on marginal costs, where all rates and charges are set equal to relevant marginal costs, with inframarginal adjustments for revenue sufficiency. No change in the total amount of revenue to be collected by the rates is contemplated. The revised rate structure would be developed by the Water Bureau, with the aid of consultants as needed, and implemented by the Bureau with the approval of the City Council.

EFFECTIVENESS

Effectiveness is estimated by the following expression:

$$E_{ijt} = Q_{jt} * R_{ijt} * C_{ijt}$$

Where: E_{ijt} = effectiveness of conservation measure i for use sector j at time t, in quantity per unit time (e.g., gallons per day)

Q_{jt} = predicted unrestricted water use in sector j at time t, in quantity per unit time (e.g., gallons per day)

R_{ijt} = fraction reduction in the use of water for sector j, at time t, expected as a result of implementing measure i.

C_{ijt} = coverage of measure in in use sector j at time t, expressed as fraction of sectoral water use affected by conservation measures.

Table 18 gives the current use pattern for the City of Atlanta Water Bureau. The values were compiled from disaggregated billing data and pumping data obtained from the Bureau. Residential refers to both single family and apartment connections. Values of the number of dwelling units served in each year were obtained from the Atlanta Regional Commission.

The range of use per dwelling unit and the range of values of percentage seasonal refer to the minimum and maximum values for the four years. There were no obvious time trends per household in the 4 years. Use per employee was estimated using Table 4 of the site description based on the assumptions (1) that 50 percent of government and manufacturing employees were in establishments classified as Non-Revenue and Industrial (respectively) and (2) that 90 percent of Fulton County businesses (i.e. employees) were served by Atlanta Water Bureau facilities in 1978. These assumptions may not actually apply to Atlanta but are used here for purposes of illustration.

Atlanta Water production averaged 107 mgd in 1978. Disaggregated per-unit forecasts for each forecast year are presented in Table 19. The number of forecast units is presented in Table 20. Table 21 presents the disaggregated forecasts. The following assumptions used in forecasting the values of use per unit were obtained from the ARC (MAWRS File, Dec. 8, 1979, T. C. Leslie). The assumption that the new Georgia State Planning Code (Act 998 passed March 14, 1978) will be implemented in 1980 was used throughout.

1. For domestic water consumption, 41 percent is for toilets and 22 percent is for showers. For commercial and public water consumption, 50 percent is for toilets and none is for showers. (Although there are showers in hotels/motels, this consumption is small when compared to the total commercial consumption. Since hotels/motels pay the water bill for guests, it is in their best interest to install water conserving showers and many have probably done so.)

2. For toilets, it is assumed that 1 percent are replaced or retro-fitted each year (i.e., each toilet has a 100-year life). For showerheads, it is assumed that 2 percent are replaced each year (i.e., each showerhead has a 50-year life). Showerheads are assumed to have a shorter life because the replacement cost is much less than for toilets ($5 vs. $70) and because showers require hot water, it is in the best interest of the owner to use less hot water to reduce the gas or electric bill.

TABLE 18

WATER USE PATTERNS: ATLANTA
(1975-1978)

Class	Total Water Use (PERCENT)	Seasonal[1] (PERCENT)	Average Gallons per Unit per day
Residential	41.4	7-14	188-199 gal/dwelling unit/ day
Commercial	24.0	15-23	80 gal/employee/day[4]
Industrial	5.5	9-15	150 gal/employee/day[4]
Non-Revenue	3.7	17-20	130 gal/employee/day[4]
Wholesale	8.1	13-21	------
Unaccounted for	17.3	-----	(8,200 gal/main.-mile/day)[3]
Total	100	10-14 7-12[2]	------

[1]From billing records: defined as

$$\left[1 - \frac{(\text{March billing (100 c.f.)} + \text{April billing (100 c.f.)}) \div 60}{\text{annual billing (100 c.f.)} \div 365}\right]$$

[2]From pumping records: defined as

$$\left[1 - \frac{\text{Average March pumping rate (mgd)}}{\text{Average annual pumping rate (mgd)}}\right]$$

[3]Average 1975-1978
[4]Approximation based on 1978 only

TABLE 19

FORECAST WATER USE PER UNIT: ATLANTA

Customer Class (Use Unit)	Use per Unit					
	1980	1990	2000	2010	2020	2030
Gallons per Dwelling-Units per Day						
New Residential Domestic	140	140	140	140	140	140
Old Residential Domestic	175	169	163	157	151	145
New Residential Seasonal	20	22	24	24	24	24
Old Residential Seasonal	20	22	24	24	24	24
Gallons per Employee per Day						
New Commercial	68	68	68	68	68	68
Old Commercial	80	79	78	76	75	74
New Industrial	113	113	113	113	113	113
Old Industrial	150	132	113	113	113	113
New Non-Revenue	111	111	111	111	111	111
Old Non-Revenue	130	128	126	124	122	120

TABLE 20

FORECAST NUMBER OF UNITS: ATLANTA

Customer Class (Unit)	Number of Units					
	1980	1990	2000	2010	2020	2030
Dwelling-Units						
Residential	223,000	306,000	400,000	494,000	588,000	682,000
Employees						
Commercial	370,000	497,000	610,000	723,000	836,000	949,000
Industrial	46,000	57,000	65,000	73,000	81,000	89,000
Local Government[1]	35,000	45,000	50,000	55,000	60,000	65,000

[1] During 1978 a program was instituted requiring interdepartmental payment by non-revenue connections. The title of this category has been changed to reflect this.

TABLE 21

WATER USE FORECAST: ATLANTA

Customer Class	Total Use per Customer Class (MGD)					
	1980	1990	2000	2010	2020	2030
Residential (Domestic)	39.0	49.3	61.1	72.9	84.8	96.6
Residential (Seasonal)	4.5	6.7	9.6	11.9	14.1	16.4
Commercial	29.6	37.9	45.2	52.1	59.4	66.7
Industrial	6.9	7.3	7.3	8.2	9.2	10.1
Local Government	4.5	5.6	6.1	6.6	7.0	7.5
Wholesale	9.2	11.6	14.0	16.4	18.4	20.4
Unaccounted for	19.6	24.8	30.0	35.2	40.4	45.6
Total	113.3	143.2	173.3	203.3	233.3	263.3
Maximum Day Capacity Desired (1.4 x Average Day)	158.6	200.5	242.6	284.6	327.3	368.6

3. Prior to 1980, it is assumed that toilets require 5 gal/flush and that showers require 6-10 gpm. After 1980, it is assumed that new toilets require 3.5 gal/flush and that new showers require 3.5 gpm. The percentage reduction in consumption is 30 percent for toilets and 50 percent for showers. (This implicitly assumes 8 gpm showers now and 15 percent longer showering times with the new 3.5 gpm showers.)

4. As a result of PL. 92-500 and PL. 95-217 (the Amendments to the Federal Water Pollution Control Act) industrial use at a given level of employment is projected to decline by 25 percent during the period 1980 to 2000. New industrial facilities are assumed to use 25 percent less water per employee.

For Table 19 the following additional assumptions were made:

1. Domestic use for new dwelling units was increased 5 percent to reflect the affluence of the residents of these new units.

2. The number of occupants per dwelling unit (D.U.) is expected to remain relatively stable and not affect domestic water use.

3. Increasing affluence is assumed to have a negligible effect on domestic water use.

4. Increasing affluence is assumed to increase seasonal water use up to 24 gal/D.U./day by the year 2000. Use is expected to remain stable thereafter.

5. Real marginal price is assumed to remain at 1978 level throughout the forecast period for all users.

Table 20 was derived from the following assumptions:

1. The number of dwelling units for 1980 and 1990 was assumed for this analysis to be 90 and 94 percent, respectively, of the projected number of dwelling units forecast for Fulton County.

2. The projected total number of employees for 1980 and 1990 were assumed for this analysis to be 91 and 95 percent of the projected number of total employees working in Fulton County for 1980 and 1990.

3. The fraction of employees in the Industrial and Local Government (formerly Non-Revenue) classes were assumed to be approximately 50 percent of the projected fractions of manufacturing and government employees, respectively.

4. Projected numbers of dwelling units and employees for the period 2000 to 2030 were not derived from local planning agencies. The values assumed here are similar to those that might be obtained under the conditions of rapid economic and population growth with declining importance of the manufacturing sector and economies of scale in local government.

Table 21 presents results obtained by multiplying values from Tables 19 and 20. New units are multiplied by new unit use factors; old units (existing in 1980) by old unit use factors. New unit water use is added to old unit use to give forecast water use for each sector. Because the leak detection-meter verification program assumed for future years is the one that has existed for 25 years, the fraction of water unaccounted-for is assumed to remain constant. Because unaccounted-for water is likely to contain a significant fraction of unrecorded use, this also implicitly assumes that the mix of meter sizes and use per meter will remain relatively constant.

ESTIMATES OF EFFECTIVENESS

Measure A1--Modest Kit Distribution

The quantity of domestic residential water saved by this measure will depend on the fraction of households that install the kit devices (coverage) and the fractional reduction per household for each device.

For this analysis it is assumed that:

1. Fifteen percent of the 1980 households will pick up the kit.

2. Of these: 90 percent will install the toilet inserts, 75 percent will install the shower inserts, and 1 percent will find and fix leaks in toilets by using the dye tablets.

3. Within the first year: 10 percent of installed devices are removed and 10 percent of the fixed toilets have renewed leaks.

4. Continued distribution of devices to one-half of one percent of old residential customers per year is assumed to more than outweigh the future removal of devices both because new water saving appliances are installed as assumed above and for other reasons. The additional effectiveness of continued distribution is not estimated.

5. The assumptions for the fraction of domestic use for toilets and shower (41 to 22 percent) and the assumed effect of 3.5 gpm shower flow (11 percent reduction in domestic residential use) are the same as above. The assumed effect of the two quart bottles is a 4 percent reduction in residential domestic use [(0.05 gal/flush - 5 gal/flush) * 0.41].

6. Toilet leaks are assumed to be 25 gpd or 14 percent of average domestic use.

All these assumptions are roughly based on values from the literature. Estimates which better reflect conditions should be used whenever possible.

Table 22 presents the effectiveness estimates for the modes

TABLE 22

EFFECTIVENESS ESTIMATE FOR MODEST DISTRIBUTION CAMPAIGN: ATLANTA (MGD)

Device	Q_{jt}	*	R_{ijt}	*	C_{ijt}	=	E_{ijt}
Toilet bottles	39.0		0.04		(0.15 x 0.90 x 0.90)		0.19
Shower inserts	39.0		0.11		(0.15 x 0.75 x 0.90)		0.43
Dye tablets	39.00		0.14		(0.01 x 0.90)		0.05
Total							0.67

distribution campaign. Total savings are 0.67 mgd, constant throughout the planning period. If 50 percent of the unaccounted-for water is actually due to meter misregistration, and if this effect is uniformly distributed between classes, then an additional 0.06 mgd will be saved for a total of 0.75 mgd nonseasonal use. This reduction would apply, therefore, to maximum day water use, average day water use, and average sewer contribution.

Measure A2--Moderate Kit Distribution

Because the kits are distributed door to door in this program it is assumed that when compared to the modes program there will be an increase in the number of households that actually install the kits. Installation figures of 25 percent for toilets (up from 0.15 * .9 = 0.135) and 20 percent for showers (up from 0.15 * 75 = 0.113) are assumed. Toilet leaks are assumed to be found in 2 percent of the households. The figures along with the computational data for effectiveness are shown in Table 23. Total savings from this program are 1.22 mgd. Using the same assumptions as above concerning unaccounted-for use gives a total saving of 1.33 mgd nonseasonal use.

Measure A3--Maximum Device Distribution

It will be assumed that 90 percent of all residential properties accept kit installation during the ten-year installation period. Of these, 10 percent are expected to experience difficulty or malfunction, rendering the devices ineffective. This gives a net effective installation fraction of 81 percent, to be installed at a uniform rate of

TABLE 23

EFFECTIVENESS ESTIMATE FOR MODEST DISTRIBUTION
CAMPAIGN: ATLANTA
(MGD)

Device	Q_{jt}	*	R_{ijt}	*	C_{ijt}	=	E_{ijt}
Toilet bottles	39.0		0.04		(0.25 * 0.90)		0.35
Shower inserts	39.0		0.11		(0.20 * 0.90)		0.77
Dye tablet	39.0		0.14		(0.02 * 0.90)		0.10
Total							1.22

8.1 percent per year for ten years. As before, new housing units constructed after 1980 are assumed to be fitted with water-saving fixtures, so the kits are not required.

The effectiveness measures are shown in Table 24. The toilet dam inserts are assumed to save 1.5 gallons/flush, or approximately 30 percent of all water used for toilet flushing. If toilet flushing represents 41 percent of domestic water use, the savings amount to 12 percent of the total. As before, the shower inserts and shower head replacements are expected to save 11 percent of residential domestic water use. The faucet aerator, in the absence of reliable reports, is assumed to reduce water use by a negligible amount.

The ultimate saving of 7.26 mgd is divided by 10 years to give the annual saving increase of 0.73 mgd. To avoid taking credit for changes in plumbing fixtures that would have occurred in the absence of the measure, this estimate is reduced by 20 percent, giving 0.58 mgd. Adjusting for the estimated meter misregistration increases the effectiveness to 0.63 mgd added each year for ten years, bringing cumulative effectiveness to 6.30 mgd.

Measure A4--Contingent Sprinkling Restrictions

In assessing the effectiveness of the sprinkling restrictions, a number of assumptions will be used.

1. Sprinkling restrictions are 30 percent effective for seasonal residential use.

TABLE 24

EFFECTIVENESS ESTIMATE FOR MAXIMUM DEVICE DISTRIBUTION: ATLANTA (MGD)

Device	Q_{jt}	*	R_{ijt}	*	C_{ijt}	=	E_{ijt}
Toilet dam	39.0		0.12		(0.90 * 0.90)		3.79
Shower heads and inserts	39.0		0.11		(0.90 * 0.90)		3.47
Faucet aerator	39.0		0.00		(0.90 * 0.90)		0.0
Total							7.26

2. Sprinkling restrictions are 15 percent effective for seasonal use by commercial, industrial, and local government establishments.

3. The sprinkling restrictions will have no effect on residential domestic water use, other nonseasonal water use, wholesale water use, and unaccounted-for water.

4. Water use reduction on the maximum day will exceed the reduction on the average summer day. However, since the conservation measure is implemented only in years having higher-than-expected maximum days, the reduction in expected maximum day is taken as 10 percent of the reduction in summer water use.

5. It is estimated that this restriction policy might be implemented in 1 year of every 10.

6. The proportion of seasonal water use to total water use will remain relatively constant throughout the projection period.

7. In computing the effectiveness figures, it is assumed that given the range of percent seasonal usage for each user class, the highest percentage of seasonal usage would be the most appropriate figure during a 'crisis' period.

Using data from Tables 18 and 21, the effectiveness data were calculated and are displayed in Table 25.

TABLE 25

EFFECTIVENESS OF SPRINKLING RESTRICTIONS: ATLANTA

	R_{jt}	C_{jt}	Q_{jt}						E_{ijt}					
			1980	1990	2000	2010	2020	2030	1980	1990	2000	2010	2020	2030
Residential seasonal	.30	1.00	4.5	6.7	9.6	11.9	14.1	16.4	1.35	2.00	2.90	3.60	4.20	4.90
Commercial	.15	.23	29.6	37.9	45.2	52.1	59.4	66.7	1.02	1.30	1.60	1.80	2.00	2.30
Industrial	.15	.15	6.9	7.3	7.3	8.2	9.2	10.1	.16	.16	.16	.18	.21	.23
Local government	.15	.20	4.5	5.6	6.[illegible]	6.6	7.0	7.5	.14	.17	.18	.20	.21	.23
Total annual reduction (mgd)									2.67	3.63	4.84	5.78	6.60	7.66
Reduction in Average summer day[1] (mgd)									8.01	10.89	14.52	17.34	19.86	22.98
Reduction in expected maximum day (mgd)									0.80	1.09	1.45	1.73	1.99	2.30

[1]Water use reduction occurs entirely in summer period, which is four months long (July through October).

Measure A5--Change in Price Structure

The price policy chosen is one where a uniform summer price is set at a level to reflect the expected incremental cost of seasonal use. The price for the rest of the year is adjusted so that the average annual unweighted price is the incremental cost of nonseasonal use. Sewer costs are assigned only to nonseasonal use. Consumptive use costs are assigned only to seasonal use. Maximum day costs are assigned to use based on the probability that the unit of use in question will occur on the maximum day.

For the specific price structure, the summer price is applied to the bimonthly billing for meter readings made in July, August, September, and October. If 1/60th of the meters are read every day in a smooth billing cycle then the 1/60 of the customers whose meters are read on July 1 would face the summer price for May 1 water use. The fraction of use billed at summer prices would increase until July 1; then throughout July and August all use would face the summer price. On September 1 this process is reversed so that by October 30 only the use by the 1/60th of the customers whose bills were read on that day would face the summer price. For Atlanta this would make the summer price highly correlated with the maximum day which normally occurs in July and August but can occur in June and September.

The maximum day costs are allocated based on the probability that a given day will be the peak. For Atlanta it is estimated that the maximum day will occur in June through September 95 percent of the time. Using the values from Table 35, the maximum day costs are applied evenly over the 122 day period to obtain the peak charge of ($164,000/mgd ÷ 122 days) * 0.000748 mg/100 c.f. * 0.95 or $0.96/100 c.f. To this must be added the average day and consumptive costs of ($112,400/mgd + $19,600/mgd) ÷ 365 days * 0.000748 mg/100 c.f.) or $0.27/100 c.f. for a total charge on all bills read from July through October of $1.23/100 c.f.

The proper charge for nonseasonal use is the sum of the maximum day, average day and sewer contribution costs again from Table 35. This value is ($104,000/mgd + $112,400/mgd + $100,600/mgd) ÷ 365 days * 0.00748 mg/100 c.f. which equals $0.77/100 c.f. In order that this be the average annual price, the price for the period November through June must be $0.54/100 c.f.

The current rate schedule adopted January 2, 1979, is of the declining block form. The marginal price for water and sewer ranges from $1.20/100 c.f. for a few very large customers to $2.41/100 c.f. for some small customers.

The prices derived according to marginal cost principles, as given above, range from $0.54/100 c.f. (winter) to $1.23/100 c.f. (summer). The same marginal cost principles would dictate that adjustments necessary to insure revenue sufficiency be confined to inframarginal charges, so that these prices would apply at the margin. Virtually all

water users, therefore, would face lower marginal prices, and would be expected to increase, not reduce, water use. A marginal cost based rate structure, therefore, is not a water conservation measure for Atlanta, and will not be evaluated further.

ADVANTAGEOUS EFFECTS

Measure A1--Modest Kit Distribution

In addition to effectiveness in saving water, another advantageous effect of this conservation measure is the amount of energy saved--primarily from the reduced use of hot water in showers. Sharpe (undated) indicates that the savings from a similar shower head device in 1975 were approximately $23.00/year/household. In December 1978 dollars, this is a value of $29.00/year. For the modest plan (assuming 15 percent of the residents pick up the kit, 75 percent install the shower device, and 10 percent are removed thereafter), a total of 22,600 households would be involved. Assuming no differential inflation of energy prices, this would provide an annualized energy-related advantageous effect of $655,000/year.

Measure A2--Moderate Kit Distribution

For the moderate program the installation factor for shower inserts is 20 percent with 10 percent removal. The participation of 40,140 residents provides an annualized energy-related advantageous effect of $1,164,000/year.

Measure A3--Maximum Kit Distribution

As previously outlined, this program assumes that 90 percent of the residents participate and that 10 percent of the devices are removed within the year first installed. This implies 8.1 percent of 1980 household units have devices permanently installed during each of the first ten years. For each household the present value of the advantageous effect is $407 (discount rate = 6.875%). Using the series present worth factor over the first 10 years yields a present value of (223,000 $407/DU 0.081 7.064) or $51.9 million. Annualized, this is $3.7 million/year for the energy-related advantageous effect of the maximum kit distribution measure.

Measure A4--Contingent Sprinkling Restrictions

No advantageous effects are anticipated beyond those resulting directly from water savings (discussed in the following evaluation).

DISADVANTAGEOUS EFFECTS: IMPLEMENTATION COSTS

Measure A1--Modest Kit Distribution

As stated previously, it is estimated that 1,100 kits will be distributed each year throughout the planning period, after the first year. Table 26 presents the implementation costs. The cost of the kits distributed in the base year is annualized over 50 years at a discount rate equal to 6.875 percent. All other costs are assumed to be uniform annual costs.

TABLE 26

IMPLEMENTATION COST FOR MEASURE A1

Item	Cost	Annualized Cost
Devices distributed in base year	33,450 * $1.12[1] = $37,460	$2,670
Devices distributed in subsequent years (per year)	1,110 * $1.12 = $ 1,240	1,240
Bill inserts (per year)		4,500
Production of television announcements (per year)		1,000
	Total Annual Cost	$9,410

[1]Each kit will contain:

a.	4 1-quart plastic bottles @ $0.10	$0.40
b.	2 dye tables @ $0.06	0.12
c.	1 shower insert @ $0.50	0.50
d.	instructions and plastic bag	0.10
	Total cost per kit	$1.12

Source: Gilbert, undated, p. III-14; costs inflated from 1977 to 1979 dollars.

Measure A2--Moderate Kit Distribution

The Moderate Kit Distribution program would use the same kit previously described. However, instead of providing kits at a central location to be picked up by residents during the first year, kits would be distributed door to door by the responsible agency. The estimated additional cost is 10 min/household @ $4/hr. = $0.67/household.

The cost of this program is shown in Table 27.

TABLE 27

IMPLEMENTATION COST FOR MEASURE A2

Item	Cost	Annualized Cost
Base year device cost	223,000 * $1.12 = $249,760	$17,810
Base year delivery cost	223,000 * 0.67 = 149,410	10,660
Annual continued distibution cost	1,100 * 1.12 = 1,240	1,240
Bill inserts (per year)		4,500
Production of television announcements (per year)		1,000
	Total Annual Cost	$35,210

Other assumptions are the same as for measure A1.

Measure A3--Maximum Kit Distribution

The maximum program would provide door to door distribution and installation (if the owner permits) of the following kit:

		Cost
An average of 1.5 plastic toilet tank dam sets	-	$8.00
An average 1-2 shower heads or flow inserts	-	4.00
An average of 1 aerator	-	2.50
Total materials cost	-	$14.50/D.U.
1.5 hr installation and subsequent inspection @ $8.50/hr	-	12.75
Total Cost		$27.25/D.U.

Assuming a 90 percent participation rate, the total expense is:

223,000 D.U. * 0.9 * $27.25/D.U. or $5.47 million.

The program is spread out over a 10-year period from 1980-1989.

Other costs of this program are the continued inspection of 2 percent of the households each year (223,000 * .02 * $8.50/hr. * 0.5 hr. = $19,000), bill inserts every year ($5,500/yr) and television announcements ($1,000/yr). Total annual recurring costs are $24,500 per year. The present value of the $5.47 million spread over 10 years is ($0.547 * 7.064) or $3.86 million. Annualizing over 50 years at 6.875 percent gives $275,500 for the annual cost of the devices and distribution. This amount plus annual recurring costs brings the total annual cost to $300,000.

Measure A4--Contingent Sprinkling Restrictions

Informing the public of water use restrictions when they become effective and explaining their application would impose costs on the Water Bureau. Some of the costs that may be expected are outlined in Table 28 (Lattie, 1977). Total media costs shown in Table 29 are based on data from Table 28.

It is assumed that the newsletter, bill insert, and public service announcement strategy would only be used during water-short years, when the sprinkling restrictions are actually in force. It will be further assumed, for purposes of demonstrating the analysis, that sprinkling restrictions must be implemented on year in ten, and that the probability of any given year being a water-short year is the same as that for any other year (equal to 0.10). The expected cost of the campaign in the base year is, therefore, 0.10 * $52,150, or $5,220. This figure is assumed to increase proportionate to the number of residential units served by the water system, approximately 2.25 percent per year

TABLE 28

MATERIAL DESIGN AND PRODUCTION COSTS (1977)

Printed Materials	Design	Printing	Quantity
Newsletter	$100-500	$25-300	1,000
Bill Inserts	$200-700	$ 6-25	1,000
<u>Broadcast Materials</u>	<u>Production</u>	<u>Per Print</u>	
Television Public Service Announcements/30 sec.	$400-1500	$8-12	

TABLE 29

MATERIAL DESIGN AND PRINTING COSTS

	Design	Printing/1,000	Household	
Newsletter	$300	$150	* 223,000 = $300 + $33,450	= $33,750
Bill Insert	$450	$ 15	* (223 X 2) = 450 + 6,690 (bill insert for 2 consecutive months)	= $ 7,140
Public Service Announcement/ 30 sec.	Production $1000			$ 1,000
Total Media Costs (1977 prices)				41,890
Total Media Costs (1979 prices)				$52,150

throughout the planning period. The present value of a series of expected annual expenditures, beginning at $5,220 and increasing at a uniform rate of 2.25 percent per year, and discounted over 50 years at 6.875 percent, is $102,770. Annualized over 50 years at the same discount rate, this is equivalent to uniform annual costs of $7,330 per year.

No significant implementation costs are expected to be borne by consumers. (Inconvenience or other costs associated with the effects of implementation must be discussed under "other adverse and beneficial effects.")

OTHER DISADVANTAGEOUS EFFECTS

Measure A1--Modest Kit Distribution

No other disadvantageous effects are anticipated.

Measure A2--Moderate Kit Distribution

No other disadvantageous effects are anticipated.

Measure A3--Maximum Kit Distribution

No other disadvantageous effects are anticipated.

Measure A4--Contingent Sprinkling Restrictions

Disadvantageous effects of the sprinkling restrictions may accrue to residents as result of possible lawn and shrubbery damage. Sprinkling restrictions such as those stated are not considered severe enough to cause significant losses. The inconvenience of the restriction is a disadvantageous effect to the extent that it disrupts household routines and causes residents to engage in various activities in a time sequence other than that which would be freely chosen. Also, the restrictions could result in improper maintenance and care of lawns and gardens, possibly causing some damage.

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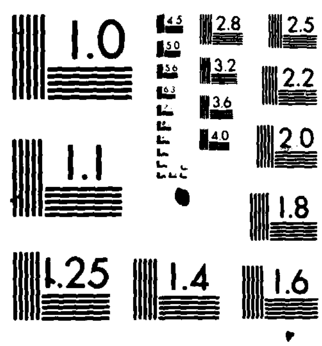

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CHAPTER V

EVALUATION OF WATER CONSERVATION MEASURES

Advantageous effects of water conservation measures consist principally of costs foregone. Reducing water use has the effect of reducing both water supply and wastewater disposal costs. Further, where water use creates external costs for parties other than the water supplier and the water user, those external costs may be reduced as well.

This section describes the identification and measurement of the short-run and long-run incremental costs likely to be affected by changes in water use. External costs are also analyzed and measured. All supply cost/water use reduction relationships are assumed to be linear over the relevant range, and the necessary coefficients are estimated. Application of these relationships to the effectiveness estimates presented in the previous section results in estimates of the advantageous effects expected to result from the implementation of the water conservation measures analyzed.

Where water conservation measures are to be considered as an element of a Federal water supply/conservation plan, some of the costs to be analyzed will be those of the Federal plan. Since several alternative Federal plans are usually evaluated (e.g., the NED plan, the EQ plan, a primarily non-structural plan, and so on), a cost analysis must be performed for each plan. Each conservation measure, therefore, will be associated with several alternative advantageous effect measures: a value which assumes that the NED plan is implemented; a value which assumes that the EQ plan is implemented; and so on. In the case of this illustrative example, no Federal water supply plans were under consideration. Water conservation advantageous effects depend entirely on local plans and facilities. Accordingly, a single estimate of advantageous effects is prepared for each water conservation measure considered.

SHORT-RUN INCREMENTAL SUPPLY COSTS

Water Supply

The relationship between short run water supply costs and the level of water use is based on analysis of the operating budget for the City of Atlanta Water Department. The most recent five years of budget data are employed, although a longer period might be desirable in some circumstances. The data of interest are actual expenditures on the operation, maintenance, and repair (OM&R) of the water source, treatment, transmission, and distribution system. Debt service payments and capital outlays are not included.

Items in the Atlanta budget are classified into one of three categories: (1) fixed (those items which are clearly unrelated to water use such as administration, billing and water quality monitoring); (2)

variable (those items very likely to be use related such as chemicals, fuel for pumps, electric power, and machinery and equipment repairs); and (3) all other items which are possible but not clearly related to water use (non-administrative salaries, general building repairs, and service to motor vehicles).

Two alternate measures of short-run incremental costs are investigated. The first, WOMR 1, is the sum of costs in groups (2) and (3) for each year; the second, WOMR 2, is the sum of costs in group (2) only. In both cases costs are deflated to 1967 dollars by using the wholesale price index for commodities (The Economic Report of the President, 1979, p. 248). These cost measures, WOMR 1 and WOMR 2, are shown in Table 30 and 31 along with total annual water use and number of residential connections for each year during the period 1974-1978. Fixed costs (group 1) are omitted since they are unaffected by water use.

The average cost of group (2) items (WOMR 2 - BG) represents a lower bound on the change in cost with respect to a change in use. The average cost of variable and potentially variable items (WOMR 1 - BG) may be treated as a tentative upper bound on short-run incremental costs. Using these bounds provides estimates ranging from \$0.055 to \$0.154 (1967 \$/1000 gal.).

This latter estimate of incremental short-run costs can sometimes be improved upon by estimating the slope of a regression line, where the line is fitted to data describing cost and water use. Table 32 presents the results of two regressions: (1) WOMR 2 on water use and number of connections, and (2) WOMR 2 on water use alone. Regressions should properly include all independent variables though to affect the dependent variable. Therefore, the first regression is the one used. The estimate obtained from the first regression is \$0.142 ± \$0.0174 (1967 \$/1000 gal.). (0.0174 represents the 90 percent confidence interval from "t" tables at 2 degrees of freedom.) This falls within the bounds calculated first and will be taken as the proper measure of short run incremental cost. Converting to December 1978 \$/mgd-year (average use) gives a value of \$112,400 ± 13,800/mgd-year, as shown:

$$\left[(0.142 \pm 0.0174)\left(\frac{1967\ \$}{1000\ \text{gal.}}\right) * 2.17\left(\frac{\text{Dec 1978 }\$}{1967\ \$}\right) * 365\left(\frac{\text{days}}{\text{years}}\right) * 1000\left(\frac{1000\ \text{gal.}}{\text{mg}}\right)\right]$$

Wastewater Disposal

Tables 33 and 34 present the data and the regression results used to estimate the short run incremental costs of sewage treatment and collection. Values are analogous to the previous section except that number of connections could not be obtained. Data are obtained, as before, from the city budget. The regression is not as successful as those on water costs. The standard error of the slope is relatively large, suggesting a wide range of estimates. Possible reasons include (1) two sewage treatment plants were closed during this period, (2) other

TABLE 30

DEPENDENT VARIABLES FOR CALCULATION
OF SHORT-RUN INCREMENTAL COSTS

Year	WOMR 1	WOMR 2
	Annual Expenditures on Variable and Potentially Variable Items (MILLION 1967 $/YEAR)	Annual Expenditures on Variable Items (MILLION 1967 $/YEAR)
1974	5.670	1.995
1975	5.490	1.672
1976	5.560	1.995
1977	5.640	2.164
1978	5.940	2.355

TABLE 31

INDEPENDENT VARIABLES FOR CALCULATION OF SHORT-
RUN INCREMENTAL COSTS

Year	BG	CONN
	Water Use (BILLION GALLONS/YEAR)	Number of Retail Connections (MILLIONS)
1974	35.886	0.1250
1975	34.490	0.1212
1976	36.661	0.1205
1977	37.633	0.1220
1978	39.137	0.1220

TABLE 32

REGRESSIONS ON WOMR 2

	WOMR 2 = $B_0 + B_1$ (BG) + B_2 (CONN) + e				WOMR 2 = $B_0 + B_1$ (BG) + e			
Independent Variable	B	Std. Error	t-Ratio	Elast.	B	Std. Error	t-Ratio	Elast.
0 Constant	-6.538	0.787	-8.3		-3.13	0.5958	-5.26	
1 BG	0.142	0.0596	23.8	2.57	0.140	0.01619	8.69	2.54
2 CONN	27.4	6.09	4.5	1.64				
R-Bar Squared = 0.993	R-Bar = 0.996				R-Bar Squared = 0.949		R-Bar = 0.974	
Std. Error of Est. = .0209		D.F. = 2			Std. Error of Est. = .0568		D.F. = 3	
Durbin-Watson Stat. = 2.47					Durbin-Watson Stat. = 1.83			

TABLE 33

SHORT-RUN SEWER COSTS

	BGS Average Sewer Flow (BILLION GALLONS/YEAR)	SOMR 1 Annual Expenditures on Variable and Potentially Variable Items (MILLION 1967 $/YEAR)	SCMR 2 Annual Expenditures on Variable Items (MILLION 1967 $/YEAR)
1974	34.310	2.073	0.726
1975	41.245	2.256	0.917
1976	45.625	2.387	0.974
1977	47.085	2.553	1.136
1978	45.990	2.763	1.430

TABLE 34

REGRESSIONS ON SOMR 2

$$SOMR\ 2 = B_0 + B_1\ (BG) + e$$

Independent Variable	B	Std. Error	T-Ratio	Beta-W	Elast.
0	-0.6337	0.7858	-0.81		
1 BGS	0.0390	.0183	2.14	0.78	1.61

R-Bar Squared = 0.471 R-Bar = 0.686

Std. Error of Est. = 0.1920 D.F. = 3

Durbin-Watson Stat. = 1.29

significant changes in plant operations were occurring, and (3) the only available 1976 data relate to appropriations, not expenditures.

A narrower range of estimated values can be obtained by using average SOMR 1 and SOMR 2 as upper and lower bounds of short-run incremental cost. This gives a range of \$0.024 to \$0.056 (1967 \$/1000 gal.). Converted to December 1978 \$/mgd as before, this gives approximately \$32,300 $\pm$ 15,600 (\$/mgd) (1978 December factor = 2.17).

LONG-RUN INCREMENTAL SUPPLY COSTS

Water Supply

One of the major capital investments that could be delayed as a result of conservation is water treatment capacity. A 20 mgd facility plus several associated transmission mains are planned for 1980 and projected to take four years to complete. At the Federal discount rate of 6.875 percent the present value of this project is \$27.93 million. At the current projected rate of growth of peak day use of 4.2 mgd/yr, similar expansion will be required every 4.76 years. The present value at 6.875 percent of the next 10 such projects (50-year planning period) is \$71.85 million for a total present value of \$99.78 million. At the current growth rate a sustained 1 mgd reduction in peak use will enable a 0.238 year delay while keeping the quality of service constant. The change in the present value of cost from this delay is $(1 - 1/1.06875)^{.238}$ times \$99.78 million which equals \$1.57 million. The annual equivalent at 6.875 percent for a 50-year life is \$111,800/mgd (peak)-year.

Because increments to capacity are planned for almost every time period (4-year projects initiated 4.76 years apart) it is reasonable to assign a value of \$111,800/mgd (peak)-year for water use reduction which occur in future years. Of course, for plans implemented at the end of year k the benefit stream begins in year k + 1.

The present value at time zero of an annual stream of A beginning at the end of year k at interest rate R and time horizon t is:

$$A * \left[\frac{(1 + R)^t - 1}{R\,(1 + R)^t} - \frac{1 + R)^k - 1}{R\,(1 + R)^k} \right]$$

annualized over t years, this value is:

$$A * \left[\frac{R(1 + R)^t}{(1 + R)^t - 1} \right] * \left[\frac{(1 + R)^t - 1}{R(1 + R)^t} - \frac{(1 + R)^k - 1}{R(1 + R)^k} \right].$$

Simplifying, this yields:

$$A * \left[1 - \frac{1 - (1 + R)^{-k}}{1 - (1 + R)^{-t}} \right]$$

When A = $111,800, R = 6.875 percent, and t = 50 years, this gives the annual equivalent benefit of a reduction after k years as:

$$111{,}800 \quad * \quad \left[1 - \frac{1 - (1.06875)^{(-k)}}{0.964} \right].$$

Prior to construction of new water treatment capacity, the fixed operation and maintenance costs associated with the increased level of capacity are not incurred. These OM&R items can be estimated through forward looking budgetary analysis of the planned treatment plant. Only those items which vary with capacity should be included. Additional administrative costs can be included if related to plant expansion. This analysis was not performed. It is assumed that, had such an analysis been made, a value of approximately $50,000/mgd-year of capacity related OM&R would have been obtained.

The first treatment plant delay has a present value of (0.238 year/mgd * $50,000/mgd-year * 20 mgd * 1.06825^{-5}) or $170,000 per mgd. The other 9 delays have a combined present value of $445,000 for a total present value of $615,000. The annual equivalent cost saving at 6.785 percent over 50 years for capacity related OM&R cost saving is $44,000 per mgd.

Calculation of OM&R cost savings from use reductions beginning in the k^{th} year in the future should be adjusted by the factor

$$\left[1 - \frac{1 - (1.06875)^{-k}}{0.964} \right]$$

(see above).

The potential cost savings associated with possible delays in augmenting transmission capacity are more difficult to estimate. Interviews with employees of the Atlanta Water Department indicate that approximately 10 percent of the scheduled improvements to distribution and transmission capacity would be unnecessary if total water use remained constant. The timing of other projects is determined by the completion dates of housing developments. Over the next five years an average of $4.6 million per year is allocated for transmission and distribution projects (not included in this figure are the transmission projects directly associated with the new water treatment plant discussed above). Ten percent of these ($0.46 million) are assumed associated with the 4.2 mgd annual growth. These values indicate a one time saving of

$109,500 from a sustained one mgd decrease in use ($0.46 million/4.2 mgd). Annualized at 6.785 percent for 50 years gives a value of $7,800/mgd/year (maximum day). Here again changes beginning in future years are adjusted by the factor $(1 - \frac{1 - 1.06875^{-k}}{.964})$. Possible savings of finished water storage capacity are taken to be negligible, based on discussions with utility employees.

<u>Wastewater Disposal</u>

Sufficient sewage treatment capacity exists for the next 30 years in Atlanta. A 50 mgd advanced waste water treatment facility completed in 2010 would satisfy the current projected rate of growth of 2.4 mgd/year until 2030. The estimated cost of such an expansion of capacity is $54 million (Flack, 1977 assuming ENR = 2700). Of these costs, one half are assumed associated with sewer flow. One mgd decrease in use would result in a 0.42 year delay for a change in the present value of costs of

of $\left[\left(\frac{1}{1.06875^{30}} - \frac{1}{1.06875^{30.42}}\right) * \$27 \text{ million}\right]$ or $0.101 million.

The annualized equivalent cost change is $7,200/mgd (sewer contribution)-year. This value applies to any reduction of water use occurring within the first 30 years. Benefits are zero for reductions after that time.

Savings can also be achieved within the next 30 years by downsizing the anticipated water-quality related improvements because of lower total use. Based on interviews with employees of the Bureau of Pollution Control, this effect is estimated to be such that a 10 percent drop in total use would induce a 1 percent change in the capital improvements program. The present value of the capital improvement program at 6.875 percent is $29.9 million. Assuming a sewer flow of 125 mgd at 12.5 mgd reduction would provide a cost saving of $0.299 million annualized and distributed over the 12.5 mgd gives a cost saving of $1,700/mgd (sewer contribution)-year.

Savings are also possible from delays in the construction of trunk sewers. Approximately $2 million/year is spent on trunk sewers to accommodate the 2.4 mgd growth in sewer flows. This gives an estimated annual savings of $\left(\frac{\$2 \text{ million/yr}}{2.4 \text{ mgd/year}} * .07132/\text{yr}\right) = \$59,400$ for water contributed to the sewer. For future years annual values must be adjusted by the factor $\left(1 - \frac{1 - (1.0685)^{-k}}{0.964}\right)$.

EXTERNAL OPPORTUNITY COSTS

There are currently four uses of the Chattahoochee River other than Atlanta Water supply: (1) navigation, (2) recreation, (3) water supply for other towns, and (4) power generation. These uses are constrained by their potentially competitive nature, and by the need to maintain minimum downstream flows during times of low streamflow.

Navigation

Even with large increases in water withdrawals by Atlanta, sufficient water would be available for navigation. Thus no changes in release rules or navigation patterns will result from changes in water use.

Recreation and Environmental Effects

Recreational and environmental values could be potentially affected in three places: (1) on Lake Sidney Lanier, (2) on the reach of the Chattahoochee River from Lake Sidney Lanier to the Atlanta water supply intake, and (3) below the Atlanta intake. In all these cases it is judged that increased water use will not impose a cost to recreational users or affect environmental values. In the absence of the consideration of Atlanta water supply, releases from Buford Dam in the summer would be confined roughly to 5-hour periods on weekday afternoons and would occur at a rate of 8,000 cfs. This is in addition to the continuous release of 650 cfs and an estimated 100 cfs added by tributaries between Buford Dam and Atlanta. Both of these are reserved for in-stream uses. This leaves 770 mgd available for metropolitan Atlanta on a weekly basis from the afternoon releases. Current projections of use for the Atlanta region (Atlanta Regional Commission, December 8, 1978) rise from 204 mgd in 1970 to 416 mgd in 2000 and 491 mgd in 2010. Further extrapolation to 2030 gives a value of 641 mgd. Thus, on a weekly basis there will be sufficient water supply for the Atlanta Region for the 50-year planning period. The changes in release rules envisioned to meet water supply needs would redistribute releases from Buford Dam within each week (more on weekends, less on weekdays) and between seasons (more in summer, less in winter). However these changes will have a negligible affect on the levels of Lake Sidney Lanier. The redistribution of releases to meet water supply needs will, if anything, have a beneficial affect on recreation between Atlanta and Buford Dam. Downstream uses are protected by a 750 c.f.s. maximum flow-by required by the Georgia State Environmental Protection Division which is included in water supply releases at Buford and Morgan Falls Dams.

Water Supply

Downstream water supply uses are affected only by the decreased dilution caused by increased consumptive uses in Atlanta. This effect is judged to be negligible.

Power

Water use by Atlanta imposes two costs on energy generation: (1) it requires changes in the release rules to guarantee sufficient flows on weekends from the upstream dams thus lowering the total value of energy produced; and (2) water consumed or diverted from the Chattahoochee River Basin is unavailable for generating electricity at downstream dams.

The following expression gives the annual cost (benefit) for one mgd more (less) water use, in terms of decreased (increased) value of hydroelectric energy from Buford Dam.

$$\text{Annual cost of one mgd (peak day)} = (\$0.03/\text{kwh} - \$0.01/\text{kwh}) * \frac{2 * 30\ \text{hr/yr}}{258\ \text{mgd}} * 145\ \text{ft.} * 8000\ \text{cfs} * 0.073\ \frac{\text{kwh}}{\text{cfs-ft}}$$

$$= \$400/\text{yr-mgd}$$

The sources of the numbers are as follows: $0.03/kwh is the assumed alternative cost of the peak electricity transferred from weekday afternoons; $0.01/kwh is the assumed alternative cost of peak electricity transferred to weekend afternoons; 2 hr. is the number of hours of release currently provided per weekend; 30 is the number of weekends that releases are currently made; 258 mgd is the current guarantee (in excess of the 650 cfs normal continuous discharge from Buford Dam ((1050 cfs - 650 cfs) * 0.646); 145 ft. is the head on Buford Dam; 8,000 cfs is the rate of flow through Buford Dam turbines; and 0.073 kw/cfs-sec is the energy conversion factor (assumes 86 percent efficiency). Any errors of estimation would primarily result from uncertainty associated with the value of electricity.

Approximately 5 hours of generation on the Morgan Falls Dam are also transferred from peak power periods to assure adequate water supplies for Atlanta but increased use will not increase this problem. On weekends and Monday, Morgan Falls Dam provides continuous releases of 1,050 cfs rather than producing peaking power (max. rate 16.8 MW or 4,500 cfs). Larger quantities of use will only increase the continuous flow on Saturday, Sunday, and Monday. As water use in Atlanta increases, further transfers of peak power will not be required. Therefore, the cost (benefit) of increased use (conservation) is near zero at Morgan Falls Dam.

The total amount of energy generated at Buford and Morgan Falls Dams is not appreciably affected by Atlanta water use. This is not the case for dams downstream from Atlanta. The cost (benefit) of increased consumptive use or diversions from the Chatahoochee Basin is given as

$$\text{Annual cost of one mgd (consumed)} = \$0.03/\text{kwh} * 660 \text{ ft.} * 0.073 \frac{\text{kw}}{\text{cfs-ft}} * 13550 \frac{\text{cfs-hr}}{\text{mgd-yr}}$$

$$= \$19{,}600/\text{mgd-yr}$$

The sources of the numbers are as follows: $0.03 kwh is the assumed alternative cost of peak electricity; 660 ft. is the feet of heat at downstream dams; 0.073 kw/cfs-ft and 13550 cfs-hr/mgd-yr are conversion factors. Here again the primary uncertainty is the value of peak electric energy.

MEASUREMENT OF FOREGONE SUPPLY COSTS

Supply Cost/Water Use Reduction Relationships

The relationships developed in the preceding sections are summarized as Table 35. Those related to short-run incremental costs derive from the analysis of water supply costs (related to average day water use) and from the analysis of wastewater disposal costs (related to average day sewer contribution). Relationships derived from analysis of long-run incremental costs refer to treatment and transmission facilities for both water supply and wastewater disposal. Water supply costs are a function of maximum day water use; wastewater disposal costs are a function of average day sewer contribution. External opportunity costs are associated with alterations in the pattern and level of electric power generation at hydroelectric sites on the Chattahoocheee River. These alterations depend on both maximum day water use (upstream sites) and average day water consumption (downstream sites). Average day water consumption is estimated as the excess of average day water use over average day sewer contribution.

All incremental costs shown are stated as annualized values over the full 50-year planning period, at a discount rate equal to 6.875 per cent. These values assume that the water use reduction is implemented in the base year. For costs other than wastewater treatment capacity costs, where measures are implemented later the annualized value can be corrected by the factor shown in the footnote to the table. The cost savings attributable to the postponement of new wastewater treatment capacity are only realized for water use reductions occurring before 2010; excess capacity is expected to exist after that date.

The cost savings are summarized according to the dimension of water use to which they refer. Changes in the level of maximum day water use are seen to alter costs at the rate of \$164,000/mgd/year; changes in average day water use alter costs at the rate of \$112,400/mgd/year. These costs are additive: A measure which reduces both average day and maximum day water use by 1.0 mgd accounts for \$164,000 + \$112,400 = \$276,400/year cost savings. If the measure also reduced average day sewer contribution by 1.0 mgd another \$100,600/year would be added, bringing the total annual cost savings to \$377,000. If the measure were not to be implemented until year 10, annual cost savings (exclusive of \$7,200 for wastewater treatment capacity) would be multiplied by the factor:

$$1 - \frac{1-1.06875^{-10}}{1-1.06875^{-50}} = 0.49194,$$

giving an annualized value of \$183,490/year. Adding back the \$7,200 gives \$190,690/year.

TABLE 35

SUMMARY OF SUPPLY COST/WATER USE REDUCTION RELATIONSHIPS: ATLANTA

Cost Category	Water Use Unit	Annual Cost Saving per Unit (50 year @ 6.875% in 1979 $)[1]
Short-Run Incremental Costs		
Water Supply	1 mgd average use	112,400 ± 13,800
Wastewater Disposal	1 mgd sewer contribution	32,300 ± 15,600
Long-Run Incremental Costs		
Water Treatment Capacity	1 mgd maximum day	111,800
Water Treatment Operation	1 mgd maximum day	44,000
Water Transmission	1 mgd maximum day	7,800
Wastewater Treatment Capacity	1 mgd sewer contribution	7,200[2]
Improvements to Wastewater Treatment Quality	1 mgd sewer contribution	1,700
Wastewater Transmission	1 mgd sewer contribution	59,400
External Opportunity Costs		
Upstream Power	1 mgd maximum day	400
Downstream Power	1 mgd consumed	19,600
Total Maximum Day	1 mgd maximum day	164,000
Total Average Day	1 mgd average use	112,400
Total Sewer Contribution	1 mgd sewer contribution	100,600[3]
Total Consumed	1 mgd consumed	19,600

[1] For implementation in 1980; if implementation occurs in later years, value is adjusted by multiplying by:

$$1 - \frac{1 - 1.06875^{-k}}{0.964}$$

where k is the first year of implementation (k = 0 for 1980).

[2] Applies only to reductions beginning before year 2010, does not vary with year of implementation.

[3] Includes $7,200 which applies only to reductions beginning before year 2010, and which does not vary with year of implementation.

FOREGONE SUPPLY COST ESTIMATES

The following sections outline the calculations of annualized advantageous effects for each of the water conservation measures under consideration. In each case, advantageous effects are calculated on the basis of effectiveness measures determined in the preceding section, using supply cost/water use reduction relationships summarized in Table 35.

Measure A1--Modest Kit Distribution

This measure reduces exclusively nonseasonal use, so that maximum day water use, and average day sewer contributions are affected. Since this measure is assumed to be fully implemented in the first year, annualized advantageous effects are taken directly from Table A32. For the three affected dimensions of water use, they total $377,000/mgd/year. Of this total, $144,700/mgd/year is associated with short-run costs of non-federal facilities, $231,900/mgd/year with long-run costs of non-federal facilities, and $400/mgd/year with external opportunity costs. There are no costs foregone for Federally planned facilities. Since the estimated effectiveness is a uniform annual reduction in water use (<u>for all three dimensions</u>) of 0.75 mgd, the annualized advantageous effect is 0.75 mgd * $377,000/mgd/year = $282,750/year. This is the sum of $108,522/year short-run costs, $173,930/year long-run costs, and $300/year external costs.

Measure A2--Moderate Kit Distribution

As in the case of Measure A1, maximum day water use, average day water use, and average day sewer contribution would be reduced by equal increments. Consumptive water use would not be affected. The estimated effectiveness is a uniform annual reduction in water use of 1.33 mgd, giving an annualized advantageous effect of 1.33 mgd * $377,000/mgd/year = $501,410/year. This total is comprised of foregone short-run costs of $192,450/year, foregone long run costs of $308,430/year and foregone external costs of $530/year.

Measure A3--Maximum Device Distribution

This measure is expected to require ten years for full implementation, with effectiveness increasing by 0.63 mgd per year. As before, maximum day water use, average day water use, and average day sewer contribution are all decreased by equal increments. For effectiveness changes after the base year, the cost savings shown in Table 35 must be adjusted for all cost elements except wastewater treatment capacity costs. These are taken at full value for all sewer contribution reductions beginning before the year 2010. Table 36 summarizes the required calculations.

The adjusted advantageous effects are based on the sum of cost savings attributed to reduction in maximum day water use, average day water use, and average day sewer contribution, reduced by the savings associated with wastewater treatment capacity costs. This total is

TABLE 36

FOREGONE SUPPLY COST CALCULATIONS FOR MEASURE A3

	Cumulative Effectiveness (MGD)	Change in Effectiveness (MGD)	Adjustment Factor	Foregone Short Run Costs (DOLLARS PER YEAR)	Foregone Long-Run Costs: w/o Wastewater Treatment (DOLLARS PER YEAR)	Foregone Long-Run Costs: w/Wastewater Treatment (DOLLARS PER YEAR)	External Costs (DOLLARS PER YEAR)	Total Advantageous Effects (DOLLARS PER YEAR)
0	0.63	0.63	1.0	91,160	141,560	146,100	250	237,510
1	1.26	0.63	0.933271	85,080	132,110	136,650	230	221,960
2	1.89	0.63	0.870834	79,290	112,180	127,820	210	207,420
3	2.52	0.63	0.812414	74,060	115,010	119,550	200	193,810
4	3.15	0.63	0.757752	69,080	107,270	111,810	190	181,080
5	3.78	0.63	0.706606	64,410	100,030	104,570	180	169,160
6	4.41	0.63	0.658750	50,050	93,250	97,790	170	158,010
7	5.04	0.63	0.613973	55,970	86,910	91,450	160	147,580
8	5.67	0.63	0.572076	52,150	80,980	85,520	140	137,810
9	6.30	0.63	0.532874	48,550	75,430	79,970	130	128,680
TOTALS				679,930		1,101,230	1,860	1,783,020

$377,000 - $7,200 = $369,800/mgd/year. Short-run and external costs are as above; long-run costs foregone are reduced to $224,700/mgd/year. Multiplied by the annual effectiveness increment, this gives 0.63 mgd * $369,800/mgd/year = $232,970/year. The remaining cost element, which does not require adjustment, is 0.63 mgd * $7,200/mgd/year = $4,540/year. This amount is added to each entry in column 6, giving the total advantageous effect increments shown in column 7. The sum of entries in column 9 is the total annualized advantageous effect attributable to Measure A3: $1,783,020/year.

Measure A4--Contingent Sprinkling Restrictions

The application of contingent restrictions on lawn and garden irrigation reduces average day water use, maximum day water use, and consumptive water use. Since all water saved is consumptively used, the savings in average day and in consumptive water use are identical. The maximum day water use reduction is considerably larger, however, due to the relative importance of sprinkling on the maximum day. The advantageous effects realized from these savings depend not only on the water use reductions, the associated cost savings, and the time of occurrence, but on the frequency with which the contingent restrictions would be implemented. It will be assumed here that Measure A4 would be invoked, on average, one year in ten, and that the probability of implementation is the same for each year in the planning period (10 percent).

Advantageous effects derived from changes in average day and consumptive water use (foregone short-run and external opportunity costs) occur only when the conservation measure is implemented. Advantageous effects calculated for one such year, therefore, are multiplied by 0.1 to give the expected value of annual advantageous effect. Long-run advantageous effects, however, associated with changes in maximum day water use, are taken at full value, since the measure acts to reduce the supply requirements.

Reductions in average day water use, and in consumptive water use, produce annualized cost savings totalling $132,000/mgd/year. Reductions in maximum day water use produce further savings equal to $164,000/mgd/year. Since effectiveness increases each year with increasing levels of overall water use, each increment to effectiveness leads to separate advantageous effect calculations, based on the year of occurrence. In order to reduce the number of calculations, it will be assumed that effectiveness increases discontinuously, with changes in years 0, 10, 20, 30, and 40. Table 37 summarizes the calculations, which yield annualized advantageous effects for sprinkling restrictions equal to $222,070 per year.

Foregone NED Benefits

Since no federal multi-purpose water supply plan is under consideration for the Atlanta region, reduction in water use will not cause NED benefits associated with other purposes to be foregone.

TABLE 37

FOREGONE SUPPLY COST CALCULATIONS FOR MEASURE A4

Year	Cumulative Effectiveness (MGD)	Change in Effectiveness (MGD)	Adjustment Factor	Adjusted Value (DOLLARS PER YEAR)	Expected Value (DOLLARS PER YEAR)
Short-Run: Average Day Water Use:					
0	2.67	2.67	1.0	300,110	30,010
10	3.63	0.96	0.496194	53,540	5,350
20	4.84	1.21	0.237073	32,240	3,230
30	5.78	0.94	0.103800	10,970	1,100
40	6.62	0.84	0.035255	3,330	330
				Total	40,020
Long-Run: Maximum Day Water Use:					
0	0.80	0.80	1.0	131,200	131,200
10	1.09	0.29	0.496194	23,600	23,600
20	1.45	0.36	0.237073	14,000	14,000
30	1.73	0.28	0.103800	4,770	4,770
40	1.99	0.26	0.035255	1,500	1,500
				Total	175,070
External Costs: Consumptive Water Use:					
0	2.67	2.67	0.0	52,330	5,230
10	3.63	0.96	0.496194	9,340	940
20	4.84	1.21	0.237073	5,630	560
30	5.78	0.94	0.103800	1,910	190
40	6.62	0.84	0.035255	580	60
				Total	6,980

Reduced Negative EQ Effects

As determined earlier in the analysis of external opportunity costs, alterations in the level or pattern of water withdrawals for Atlanta's water supply appear to have negligible effects on other uses of the Chattahoochee River, with the exception of hydropower generation. Accordingly, no significant negative EQ effects are expected to be foregone as a result of water use reductions.

Increased Negative EQ Effects

Analysis of the uses of the Chattahoochee River has failed to identify any negative EQ effect which would be increased as a result of water use reductions. To the extent that the imposition of sprinkling restrictions may result in lawn and garden damage, the change in the appearance of residential neighborhoods could constitute a negative EQ effect. Consideration of the relatively moderate nature of the sprinkling restrictions proposed, and the contingent nature of their implementation, suggests that any EQ effects would be very small to zero. No increased negative EQ effects are anticipated, therefore, for any of the conservation measures studied.

Summary of Evaluation

The four water conservation measures studied for Atlanta have been reviewed for advantageous and disadvantageous effects, with respect to both the NED and EQ objectives. The effects which have been identified and measured are summarized on Tables 38 and 39. The combined advantageous NED effects outweigh the combined disadvantageous NED effects in every case; a possible negative EQ effect appears in only one case (Measure A4). All four measures are, therefore, eligible for possible inclusion in a water conservation proposal.

TABLE 38

SUMMARY OF NED ADVANTAGEOUS AND DISADVANTAGEOUS EFFECTS OF WATER CONSERVATION MEASURES[1]

	A1--Modest Kit Distribution	A2--Moderate Kit Distribution	A3--Max. Device Distribution	A4--Contingent Sprinkling Res.
	(DOLLARS PER YEAR)			
ADVANTAGES				
a. Unrelated to water use reduction	- 0 -	- 0 -	- 0 -	- 0 -
b. Indirectly related to reduction	655,000	1,164,000	3,700,000	- 0 -
c. Foregone supply cost				
i. short-run/federal plan	- 0 -	- 0 -	- 0 -	- 0 -
ii. long-run/federal plan	- 0 -	- 0 -	- 0 -	- 0 -
iii. short-run/non-federal facilities	108,520	192,450	679,930	40,020
iv. long-run/non-federal facilities	173,930	308,430	1,101,230	175,070
v. external opportunity costs	300	530	1,860	6,980
d. Total NED Advantages	937,750	1,165,410	5,783,020	222,070
DISADVANTAGES				
a. Implementation costs	9,410	35,210	300,000	7,330
b. Other disadvantageous effects	- 0 -	- 0 -	- 0 -	(possible unquantified damage to lawns, gardens; inconvenience)
c. Foregone NED benefits	- 0 -	- 0 -	- 0 -	- 0 -
d. Total NED Disadvantages	9,410	35,210	300,000	7,330

[1]Effects shown are for implementation of each measure individually; NED effects are in annualized $/year.

TABLE 39

SUMMARY OF EQ ADVANTAGEOUS AND DISADVANTAGEOUS EFFECTS OF WATER CONSERVATION MEASURES

	A1--Modest Kit Distribution	A2--Moderate Kit Distribution	A3--Max. Device Distribution	A4--Contingent Sprinkling Res.
EQ EFFECTS				
ADVANTAGES				
a. Unrelated or indirectly related to water use reduction	none anticipated	none anticipated	none anticipated	none anticipated
b. Directly related to water use reduction				
i. federally planned facilities	n/a	n/a	n/a	n/a
ii. non-federal facilities	none anticipated	none anticipated	none anticipated	none anticipated
c. Total EQ advantages	none	none	none	none
DISADVANTAGES				
a. Unrelated or indirectly related to water use reduction	none anticipated	none anticipated	none anticipated	none anticipated
b. Directly related to water use reduction				
i. federally planned facilities	n/a	n/a	n/a	n/a
ii. non-federal facilities	none anticipated	none anticipated	none anticipated	none anticipated
c. Total EQ disadvantages	none	none	none	none

CHAPTER VI

INTEGRATION OF WATER CONSERVATION INTO WATER SUPPLY PLANS

ELIGIBLE WATER CONSERVATION MEASURES

The evaluation of five representative water conservation measures for Atlanta resulted in four measures which meet eligibility criteria. As described in previous sections, these measures all meet the tests of applicability, feasibility, acceptability, and effectiveness, as well as providing net advantageous effects with respect to the NED objective, the EQ objective, or both. The eligible measures are listed again in Table 40, which also summarizes the information necessary to place these measures in merit order. All of the measures shown are both technically feasible and socially acceptable. Had any of them been found potentially feasible or potentially acceptable, the nature of the qualification would have been noted on the table.

As stated earlier, consideration of alternative Federal water supply plans will, in general, lead to alternative estimates of the effects for individual water conservation measures. For a given measure, each alternative estimate of advantageous and disadvantageous effects is contingent on the implementation of one of the Federal plans under consideration. In order to develop a water conservation proposal for incorporation as an element in one of the Federal plans, the estimates used must be those derived from the water supply element of that plan.

In the case of this illustrative example, no Federal water supply plans were under consideration at the time of data collection. The advantageous effects developed in the previous section derive from the characteristics of local plans and facilities only. In order to illustrate the process of integrating water conservation into a water supply plan, however, this section is written as though two Federal plans existed: a NED plan and an EQ plan. The same set of advantageous effect estimates is used in each case, although in practice separate sets of estimates would be available.

NED PROJECT PLAN

Merit Order

For purposes of preparing a water conservation proposal for integration into a water supply plan, eligible measures are placed in the appropriate merit order. In the case of the NED project plan, measures are placed in order of decreasing net NED advantageous effect. The resulting merit order is shown as Table 41. Advantageous and disadvantageous effects are stated as annualized values, based on a 6.875 percent discount rate and a 50-year planning period.

TABLE 40

SUMMARY OF WATER CONSERVATION MEASURES: ATLANTA

		Advantageous Effects		Disadvantageous Effects	
Measure	Average Annual Effectiveness[1]	NED	EQ and Non-Quantified NED	NED	EQ and Non-Quantified NED
	MGD	(DOLLARS PER YEAR)		(DOLLARS PER YEAR)	
A1-Modest Kit Distn.	0.67	937,750	None identified	9,410	None identified
A2-Moderate Kit Distn.	1.22	1,665,410	None identified	35,210	None identified
A3-Maximum Device Distn.	7.26	5,483,020	None identified	300,000	None identified
A4-Contingent Sprinkling Restrictions	0.52	222,070	None identified	7,330	Occasional minor lawn & shrubbery damage; inconvenience

[1] Average annual effectiveness is equal to 0.10 (probably of implementation) times amounts calculated earlier.

TABLE 41

NED MERIT ORDER
(DOLLARS PER YEAR)

	NED Effects		
Measure	Advantageous	Disadvantageous	Net Effects
A3	5,483,020	300,000	5,183,020
A2	1,665,410	35,210	1,630,200
A1	937,750	9,410	928,340
A4	222,070	7,330	214,740

First Trial

The first trial proposal consists of the measure with the largest net advantage, measure A3. Its characteristics are the same as those shown for measure A3 on Table 40, and those shown on the first line of Table 42.

Second Trial

The second trial proposal consists of the first proposal, with the next-best measure added: measure A2. This measure can be seen to exhibit considerable interaction with measure A3, already in the proposal. Implementing both together would produce advantageous effects which are smaller than the sum of effects for A2 and A3 implemented separately. The only advantageous effects from A2, when added to A3, are attributable to those residents not scheduled for device installation for several years who would install door-distributed kits immediately.

It is assumed that residents would not install kits if the devices are scheduled for installation within one year. This would mean that door-to-door kit distribution would have 80 percent of the effectiveness previously calculated for the first year (10 percent will have devices installed, and 10 percent will anticipate installation within one year), 70 percent the second year, 60 percent the third year, and so on. Calculating foregone supply cost for this interim implementation yields a present value of $1,458,000, equivalent to an annualized value of $104,010 per year. The other advantageous effects due to lower energy use are also changed, to $221,740 per year, for a total NED advantageous effect of $325,750 per year. When added to the $5,483,020 advantageous effect produced by measure A3, this gives a total NED advantageous effect of $5,808,770 for measures A2 and A3, implemented together.

Examination of implementation costs for measure A2 reveals that these costs can be reduced under joint implementation conditions. Specifically, proper coordination with the implementation of the device installation program could result in distributing bottles to only 80 percent of the total residences. Also, the continued annual distribution cost, the cost of bill inserts, and the cost of television messages could be confined to the first eight years. These changes would reduce the annualized value of measure A2 implementation cost to $25,660 per year.

Comparison of advantageous and disadvantageous effects for measure A2, adjusted for interaction with measure A3, indicates a net advantage of $300,090. Neither the advantageous nor the disadvantageous effects of measure A3 would be affected by the prior implementation of measure A2. Measure A3 should be retained in the proposal, therefore, since it continues to contribute to net NED advantage. The proposal now consists of measures A3 and A2. Advantageous and disadvantageous effects are the sums of adjusted values for measure A2, and full values for measure A3. These totals are shown on Table 42 for NED proposal 2.

TABLE 42

SUMMARY OF TRIAL WATER CONSERVATION PROPOSALS: ATLANTA

Water Conservation Proposal	Measures	Average Annual Effectiveness (MGD)	Advantageous Effects NED (DOLLARS PER YEAR)	EQ and Non-Quantified NED Effects	Disadvantageous Effects NED Effects (DOLLARS PER YEAR)	EQ and Non-Quantified NED Effects	Net NED Advantage
NED Project Plan							
1.	A3	7.26	5,483,020	None identified	300,000	None identified	5,183,020
2.	A3, A2	7.37	5,808,770	None identified	325,660	None identified	5,483,110
3.	(no change)						
4.	A3, A2, A4	7.89	6,030,840	None identified	332,990	occasional minor lawn & shrubbery damage; inconvenience	5,697,850
EQ Project Plan							
1.	A3	7.26	5,483,020	None identified	300,000	None identified	5,183,020
2.	A3, A2	7.37	5,808,770	None identified	325,660	None identified	5,483,110
3.	(no change)						
4.	(no change)						

Third Trial

The third trial consists of the second proposal, with the next-best measure added: measure A1. Measures A2 and A1, however, are virtually mutually exclusive. Implementing one would largely replace the other. If the two measures were implemented together, the effectiveness of the combined measures would be equal to the effectiveness of measure A2: residents would not be expected to go to the central distribution points to pick up kits that would be delivered door-to-door. Similarly, implementation costs for the combined measures would be those of measure A2. Measure A2 completely dominates measure A1: Adding A1 to the proposal would change neither advantageous nor disadvantageous effects. The third trial proposal, therefore, is unchanged from the second.

Fourth Trial

The fourth trial consists of the third proposal, with the final measure added: measure A4. Examination of the characteristics of the third trial proposal (consisting of measures A3 and A2) and measure A4 discloses no apparent interaction between them. The characteristics of the fourth trial proposal, therefore, are the sums of those for the third proposal and measure A4. Since net NED advantageous effects are increased, measure A4 is retained. All eligible measures have been tested, so the fourth trial proposal is the final NED water conservation proposal.

EQ PROJECT PLAN

Merit Order

For purposes of preparing a water conservation proposal suitable for inclusion in the EQ project plan, eligible measures are placed in merit order according to net contribution to the environmental quality objective. Where there is no difference between measures with respect to the EQ objective, they are placed in their NED merit order. For the four measures analyzed for Atlanta, only the contingent sprinkling restrictions appear to affect the EQ objective; that measure is responsible for a small disadvantageous effect due to possible vegetation damage. The appropriate merit order, therefore, is shown as Table 43.

PROPOSAL DEVELOPMENT

First Trial

The first trial proposal consists of the measure ranked first in merit order, Measure A3. Its characteristics, shown on Table 40, are repeated on Table 42.

TABLE 43

EQ MERIT ORDER

Measure	Environmental Effects	Net NED Advantage
A3	none identified	5,183,020
A2	none identified	1,630,200
A1	none identified	928,340
A4	occasional minor damage to lawns and shrubbery	214,740

Second Trial

The second trial proposal consists of the first proposal, with the next best measure added: Measure A2. Again, this measure and Measure A3 already included in the proposal are seen to interact. The characteristics of the two measures are shown on Table 42 and are obtained from the analysis in the previous section. Since there is no net disadvantageous effect on the EQ objective, Measure A2 is retained.

Third Trial

The third trial proposal consists of the second proposal, with the next best measure added: Measure A1. As noted above, however, Measure A1 is completely dominated by Measure A2, already in the proposal. Inclusion of Measure A1 would have no advantageous or disadvantageous effect on the EQ objective. The characteristics of the third trial proposal are unchanged from the second, therefore.

Fourth Trial

The fourth trial proposal consists of the third proposal, with the next best measure added: Measure A4. Adding this measure, however, results in a proposal which exhibits a net disadvantageous effect on environmental quality. Although probably quite small in magnitude, damage to vegetation may result from implementation of the sprinkling restrictions. Measure A4 is rejected, therefore, and the final water conservation proposal for inclusion in the EQ project plan is identical to trial proposal 2, consisting of Measures A2 and A3.

DOCUMENTATION OF SELECTED PROPOSALS

Applicable Water Conservation Measures

The water conservation measures found applicable in the Atlanta area are listed by general category on Table 16. Those applicable measures which were subjected to further analysis in this study appear on Table 44, together with indication of technical feasibility, social acceptability, eligibility, and subsequent integration into water supply plans.

Measures Already Implemented

Water conservation measures already implemented or scheduled for implementation in Atlanta are shown on Table 45.

Federal Water Supply Plans

As discussed earlier, no Federal water supply plan exists for the Atlanta area at the time of this study. In order to illustrate the process of formulating water conservation proposals and integrating those proposals into water supply plans, however, this section has been prepared as though Federal plans existed. Two Federal water supply plans are assumed: a NED plan and an EQ plan. Since all advantageous and disadvantageous effects for water conservation measures were based on non-Federally planned facilities, these effects do not differ between the plans, as would be expected. Also, in summarizing the effects of the proposals, the columns provided for foregone Federal project cost are blank. No descriptions of the Federal plan with and without the conservation element are provided, as required by the procedures.

NED Project Plan

The water conservation proposal which is to be integrated into the NED water supply plan consists of measures A2, A3, and A4. The proposal is described on Tables 46 through 50.

TABLE 44

SUMMARY OF APPLICABLE WATER CONSERVATION MEASURES: ATLANTA

Measure	Technical Feasibility	Social Acceptability	Net Impact: NED Objective	Net Impact: EQ Objective	Eligible	Included: NED Plan	Included: EQ Plan
A1--Modest Kit Distribution	Feasible	Acceptable	positive	none	yes	no	no
A2--Moderate Kit Distribution	Feasible	Acceptable	positive	none	yes	yes	yes
A3--Maximum Device Distribution	Feasible	Acceptable	positive	none	yes	yes	yes
A4--Contingent Sprinkling & Restrictions	Feasible	Acceptable	positive	negative	yes	yes	no
A5--Change in Price Structure	Infeasible	Acceptable	--	--	--	--	--

TABLE 45

WATER CONSERVATION MEASURES IMPLEMENTED
OR PLANNED FOR IMPLEMENTATION
IN ATLANTA: 1979

Plumbing Codes for New Structures. In 1977, the Georgia State Legislature enacted House Bill No. 546, which specifies that, after January 1, 1978, no building shall be erected or substantially remodelled which:

"(1) Employs a tank-type water closet that uses more than an average of 2.5 gallons per flush; or

(2) Employes a shower head that allows a flow of more than an average of 3.5 gallons of water per minute."

Metering. The service area of the Atlanta Water Bureau is 100 percent metered.

Leak Detection. The Atlanta Water Bureau maintains an effective leak detection and repair program of more than 25 years standing.

TABLE 46

ATLANTA NED WATER CONSERVATION PROPOSAL: MEASURES

Description of Measures

A2--Moderate Kit Distribution Program: A do-it-yourself water conservation kit (consisting of 4 1-quart plastic bottles for displacing volume in toilet tanks, 1 shower insert for reducing flow, and 2 dye tablets for detecting toilet tank leaks) will be distributed door-to-door to all residential units. The proper use of the kit will be facilitated by information included in the package, by the use of water bill inserts, and by public service television announcements. Kits will not be distributed to premises scheduled for implementation of measure A3 within the first two years.

A3--Maximum Device Distribution: Door-to door distribution and free installation will be offered for toilet tank dam sets, shower head inserts or replacement shower heads, and faucet aerators. This program will be carried out over a ten-year period.

A4--Contingent Sprinkling Restriction: Whenever the Atlanta Water Bureau determines that water supply deficits are likely to occur in a given year, all residential lawn and garden irrigation will be restricted to the hours of midnight through noon on alternate days. The same restrictions will apply to other customers, except commercial florists and plant nurseries. The operation of ornamental fountains, reflecting ponds and water displays will be terminated. Water users will be encouraged to minimize all outdoor uses.

Implementation Details

The implementation and coordination of all measures will be initiated and directed by the Water Bureau. Volunteer organizations, such as Boy Scouts, Girl Scouts, and so on, will be used to distribute Measure A2 kits. Distribution and installation of Measure A3 devices will be handled by Water Bureau employees. Sprinkling restrictions will be imposed and enforced by Water Bureau personnel, given appropriate legal authority.

All existing residential units in Atlanta will be scheduled for distribution of the Measure A3 devices over a ten-year period, with one-tenth being distributed each year. The Measure A2 kits will be distributed in the first year to all residential units except those scheduled for Measure A3 devices in year one or year two. Sprinkling restrictions will be imposed as needed; it is estimated that implementation of this measure will occur, on the average, one year in ten. Measures A2 and A3 apply to residential users only (including apartments), Measure A4 applies to all water users except as noted above.

TABLE 47

ATLANTA NED WATER CONSERVATION PROPOSAL: IMPLEMENTATION COSTS

Measure	Cost (Annualized $/Year)
A2	$ 25,660
A3	300,000
A4	7,330
Total	$332,990

TABLE 48

ATLANTA NED WATER CONSERVATION PROPOSAL: EFFECTIVENESS

Measure	Water Use Reduction (MGD)					
	1980	1990	2000	2010	2020	2030
<u>Maximum Day Water Use</u>						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
A4	0.80	1.09	1.45	1.73	1.99	2.30
TOTALS	2.49	7.39	7.75	8.03	8.29	8.60
<u>Average Day Water Use</u>						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
A4[2]	2.67	3.68	4.84	5.78	6.60	7.66
TOTALS[2]	4.36	9.93	11.14	12.08	12.90	13.96
<u>Average Day Sewer Contribution</u>						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
A4	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS	1.69	6.30	6.30	6.30	6.30	6.30
<u>Average Day Water Consumed</u>						
A2	0.0	0.0	0.0	0.0	0.0	0.0
A3	0.0	0.0	0.0	0.0	0.0	0.0
A4[2]	2.67	3.63	4.84	3.78	6.60	7.66
TOTALS[2]	2.67	3.63	4.84	5.78	6.60	7.66

[1] All Measure A2 kits are replaced with Measure A3 devices.
[2] Effectiveness when sprinkling restrictions are implemented; effectiveness is zero otherwise.

TABLE 49

ATLANTA NED WATER CONSERVATION PROPOSAL: NED OBJECTIVE

Changes in Beneficial Effects (Annualized $/Year)

Measure	Foregone Non-Federal Supply Cost[1,2]	Other Advantageous Effects[3]	Net Increase in Beneficial Effects
A2	104,010	221,740	325,750
A3	1,783,020	3,700,000	5,483,020
A4	222,070	- 0 -	222,070
Totals	2,109,100	3,921,740	6,030,850

Changes in Adverse Effects (Annualized $/Year)

Measure	Implementation Costs	Other Disadvantageous Effects[3]	Less: Foregone Federal Supply Costs[4]	Net Increase In Adverse Effects
A2	25,660	- 0 -	- 0 -	25,660
A3	300,000	- 0 -	- 0 -	300,000
A4	7,330	- 0 -	- 0 -	7,330
Totals	332,900	- 0 -	- 0 -	332,990

[1]Existing and locally planned facilities, foregone supply cost
[2]Includes foregone external opportunity costs
[3]Unrelated and indirectly related to water use reduction
[4]Federally planned facilities, foregone supply cost

TABLE 50

ATLANTA NED WATER CONSERVATION PROPOSAL: EQ OBJECTIVE

Changes in Beneficial Effects

Measure	Reduction in Non-Federal Negative EQ Effects	Other Advantageous Effects[1]	Net Increase in Beneficial Effects
A2	none	none	none
A3	none	none	none
A4	none	none	none

Changes in Adverse Effects

Measures	Increase in Negative EQ Effects: Federal[2]	Non-Federal[1]	Other Disadvantageous Effects[2]	Less Reduction in Federal Negative EQ Effects[3]	Net Increase in Adverse Effects
A2	none	none	none	none	none
A3	none	none	none	none	none
A4	none	none	(occasional minor lawn & garden damage)	none	positive

[1]Existing and locally planned facilities, foregone supply cost
[2]Unrelated and indirectly related to water use reduction
[3]Federally planned facilities, foregone supply cost

EQ Project Plan

The water conservation proposal which is to be integrated into the EQ water supply plan consists of measures A2 and A3. The proposal is described in Tables 51 through 55.

TABLE 51

ATLANTA EQ WATER CONSERVATION PROPOSAL: MEASURES

Description of Measures

A2--Moderate Kit Distribution Program: A do-it-yourself water conservation kit (consisting of 4 1-quart plastic bottles for displacing volume in toilet tanks, 1 shower insert for reducing flow, and 2 dye tablets for detecting toilet tank leaks) will be distributed door-to-door to all residential units. The proper use of the kit will be facilitated by information included in the package, by the use of water bill inserts, and by public service television announcements. Kits will not be distributed to premises scheduled for implementation of measure A3 within the first two years.

A3--Maximum Device Distribution: Door-to-door distribution and free installation will be offered for toilet tank dam sets, shower head inserts or replacement shower heads, and faucet aerators. This program will be carried out over a ten-year period.

Implementation Details

The implementation and coordination of all measures will be initiated and directed by the Water Bureau. Volunteer organizations, such as Boy Scouts, Girl Scouts, etc., will be used to distribute Measure A2 kits; Distribution and installation of Measure A3 devices will be handled by Water Bureau employees.

All existing residential units in Atlanta will be scheduled for distribution of the Measure A3 devices over a ten-year period, with one-tenth being distributed each year. The Measure A2 kits will be distributed in the first year to all residential units except those scheduled for Measure A3 devices in year one or year two. These measures apply to residential users only (including apartments).

TABLE 52

ATLANTA HQ WATER CONSERVATION PROPOSAL: IMPLEMENTATION COSTS

Measures	Cost (Annualized $/Year)
A2	23,660
A3	300,000
Total	323,660

TABLE 53

ATLANTA EQ WATER CONSERVATION PROPOSAL: EFFECTIVENESS

Measure	Water Use Reduction (MGD)					
	1980	1990	2000	2010	2020	2030
Maximum Day Water Use						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
Totals	1.69	1.20	6.30	6.30	6.30	6.30
Average Day Water Use						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
Totals	1.69	6.30	6.30	6.30	6.30	6.30
Average Day Sewer Contribution						
A2	1.06	0.0[1]	0.0	0.0	0.0	0.0
A3	0.63	6.30	6.30	6.30	6.30	6.30
Totals	1.69	6.30	6.30	6.30	6.30	6.30
Average Day Water Consumed						
A2	0.0	0.0	0.0	0.0	0.0	0.0
A3	0.0	0.0	0.0	0.0	0.0	0.0
Totals	0.0	0.0	0.0	0.0	0.0	0.0

[1] All Measure A2 kits are replaced with Measure A3 devices.

TABLE 54

ATLANTA EQ WATER CONSERVATION PROPOSAL: EQ OBJECTIVE

Changes in Beneficial Effects

Measure	Reduction in Non-Federal Negative EQ Effects	Other Advantageous Effects[2]	Net Increase in Beneficial Effects
A2	none	none	none
A3	none	none	none

Changes in Adverse Effects

Measures	Increase in Negative EQ Effects: Federal[2]	Increase in Negative EQ Effects: Non-Federal[1]	Other Disadvantageous Effects	Less Reduction in Federal Negative EQ Effects[3]	Net Increase in Adverse Effects
A2	none	none	none	none	none
A3	none	none	none	none	none

[1] Existing and locally planned facilities, foregone supply cost
[2] Unrelated and indirectly related to water use reduction
[3] Federally planned facilities, foregone supply cost

TABLE 55

ATLANTA EQ WATER CONSERVATION PROPOSAL: NED OBJECTIVE

Changes in Beneficial Effects (Annualized $/Year)

Measure	Foregone Non-Federal Supply Cost[1,2]	Other Advantageous Effects[3]	Net Increase in Beneficial Effects
A2	104,010	221,740	325,750
A3	1,783,020	3,700,000	5,483,020
Totals	1,887,030	3,921,740	5,808,770

NED OBJECTIVE

Changes in Adverse Effects (Annualized $/Year)

Measure	Implementation Costs	Other Dis-advantageous Effects[3]	Less: Foregone Federal Supply Costs[4]	Net Increase In Adverse Effects
A2	25,660	- 0 -	- 0 -	25,660
A3	300,000	- 0 -	- 0 -	300,00
Totals	325,660	- 0 -	- 0 -	325,660

[1] Existing and locally planned facilities, foregone supply cost
[2] Includes foregone external opportunity costs
[3] Unrelated and indirectly related to water use reduction
[4] Federally planned facilities, foregone supply cost

Performance of Water Supply/Conservation Plans Under Drought Conditions

Since no Federal water supply plans were under consideration for Atlanta at the time of this study, no examination was made of the performance of these plans under drought conditions. Table 56 indicates the information which such a study would be expected to yield.

TABLE 56

PERFORMANCE UNDER DROUGHT CONDITIONS[1]
(MGD)

Project Plan	Maximum Day Supply Capability	Maximum Day Water Use Without Emergency Measures	Effectiveness of Emergency Measures	Deficit
NED Project Plan				
Without conservation	--	--	--	--
With conservation	--	--	--	--
EQ Project Plan				
Without conservation	--	--	--	--
With conservation	--	--	--	--

[1] All data are for year 2030, under design drought (critical low streamflow) conditions.

TUCSON DATA

CHAPTER VII

GENERAL SITE DESCRIPTION: TUCSON, ARIZONA

INTRODUCTION

The city of Tucson is located in the southeastern region of Arizona along the Santa Cruz River (Figure 12). The metropolitan area, with a population of more than 400,000 persons, lies in the eastern section of Pima County at an elevation of 2400 feet above sea level (Figure 13). Pima County also comprises the Tucson Standard Metropolitan Statistical Area (SMSA) and has a total 1975 population of approximately 450,000 persons. Tucson is the only major city in Pima County and is the county seat, as well as the second largest city in the state of Arizona.

HISTORICAL GROWTH AND DEVELOPMENT

Tucson derives its name from a Papago word pronounced "Chukson." The meaning of the word is "black hill" which describes the black volcanic formation near the city. Tucson has been inhabited for at least 10,000 years and its first known residents were Pima and Papago Indians. It was settled in the 18th century by the Spanish; and Tucson's common name, The Old Pueblo, evolved from this period. The original mud pueblo was constructed in 1776 and was the home of the Royal Presidio of San Agustin de Tucson and the mission of San Xavier which was begun in 1700 by Padre Kino.

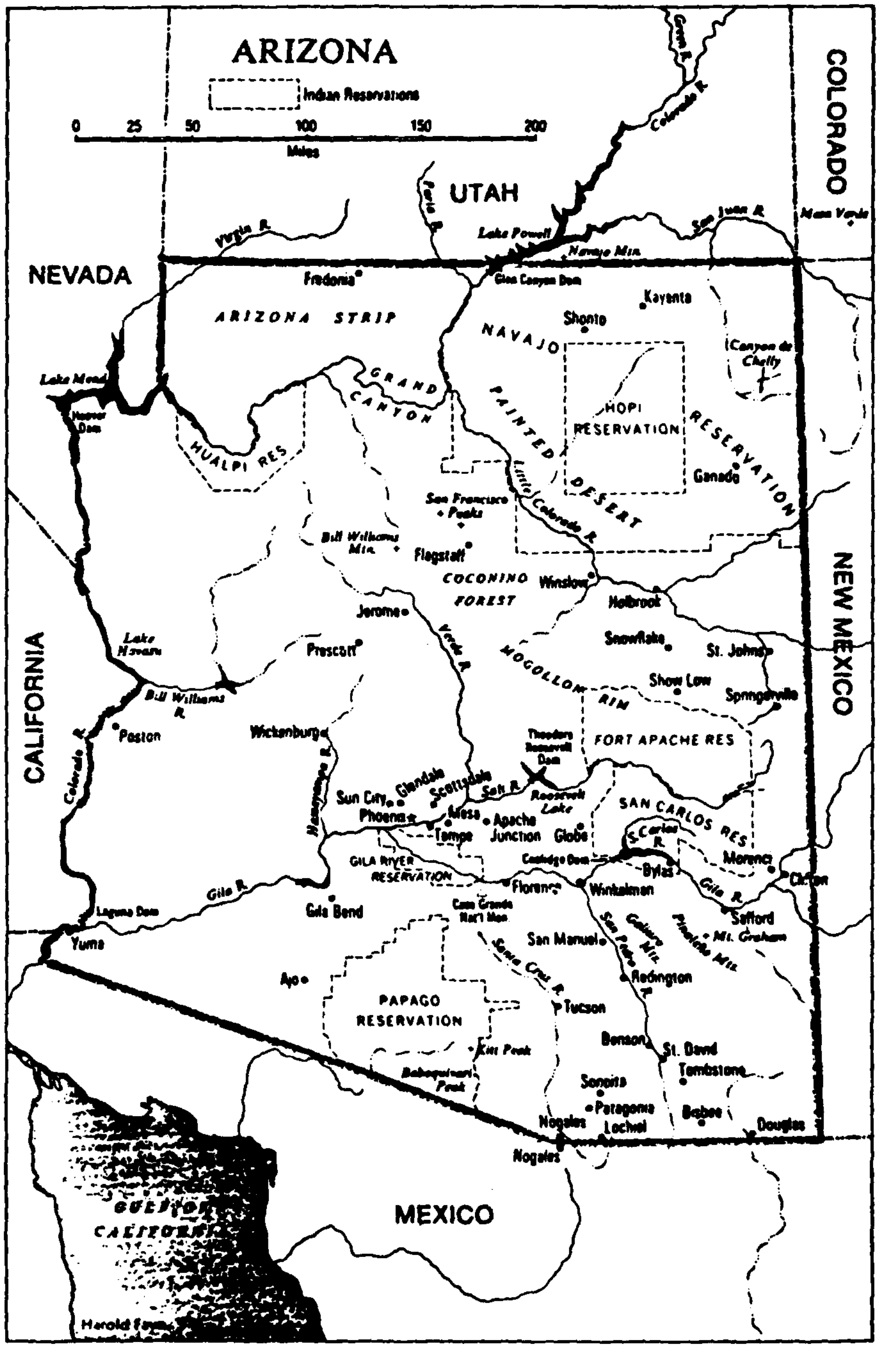
European traders and Mexican immigrants settled in Tucson and formed a town varied in cultures and traditions. The town grew as a trading center for mines, ranches and military posts. In 1857, a dam was built on the Santa Cruz River to power Solomon Warner's grinding mill and create Silver Lake which became a social center for boating, bathing, and picnicking (Powell, 1976). By 1870 Tucson, with a predominantly hispanic population of 3,200, was characterized by Powell (1976) as a "rough and lawless place, its saloons spewing brawlers into the mud or dust at all hours of day and night rivaled only by Los Angeles as the Southwest's most iniquitous sink."

On March 12, 1880, the railroad arrived in Tucson and the town's relative isolation ended. Today the city is split in two by the railroad tracks and the freeway. Northeast of this division line the population is predominantly Anglo; southwest it is Hispanic. Powell (1976) describes this dichotomy by stating that "The lifestyle of the Catalina foothills and of the eastern flatlands resembles that of Phoenix and Los Angeles, in which the dominant activities are poolside, lakeside, and at bridge and buffet tables, while the west side of the Santa Cruz south from St. Mary's Road is largely Sonoran 'in language and culture,' and is the home of Tucson's poor and working class."

Today the city is an important trade center serving central and

FIGURE 12

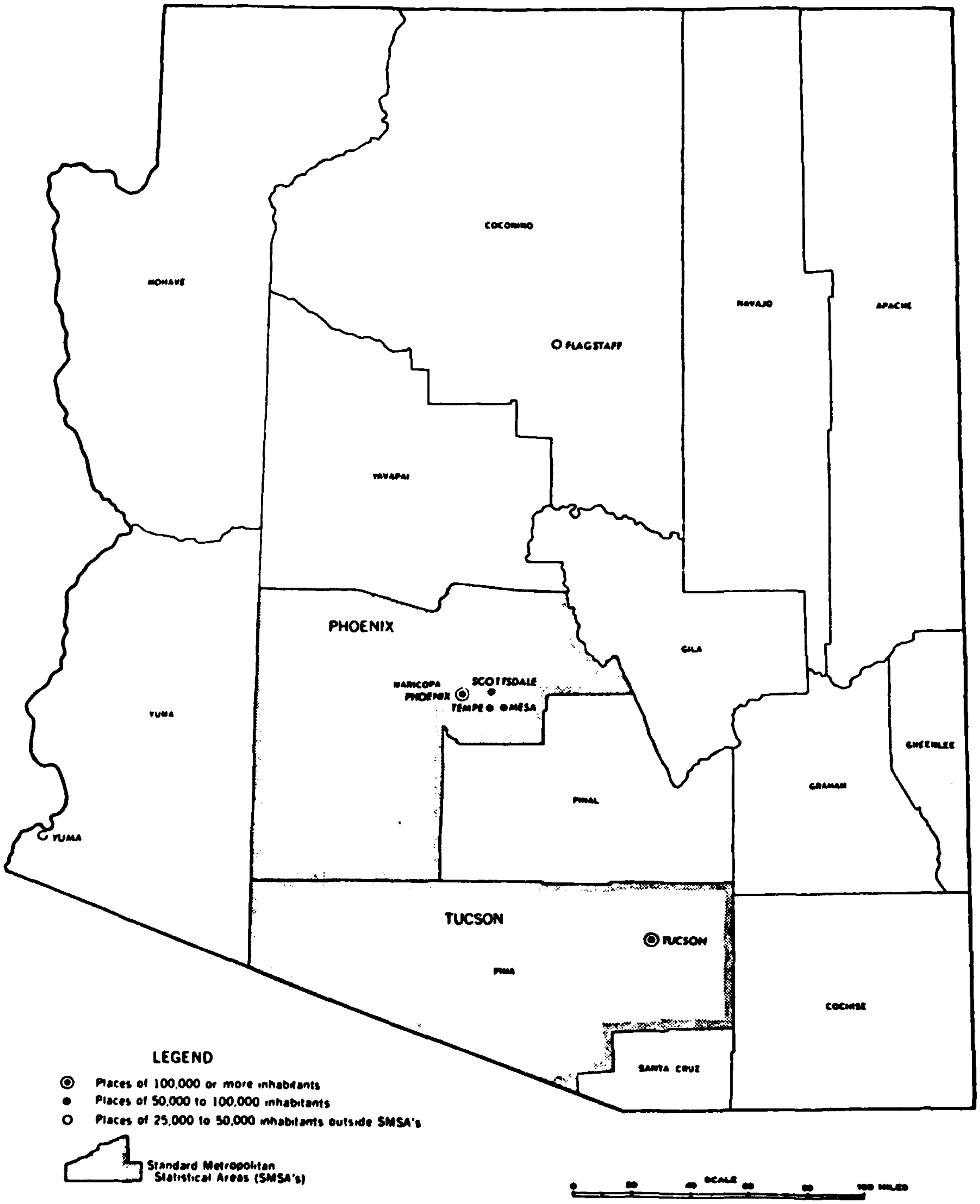
STATE OF ARIZONA



Source: Powell (1976)

FIGURE 13

ARIZONA: COUNTIES, CITIES, AND SMSA'S



Source: Bureau of the Census (1972)

southern Arizona and northern Mexico. It is the location of the University of Arizona, and the Davis-Monthan Air Force Base. The Federal government is the largest source of income in the area. Revenue from the copper mining industry is yet another component of Tucson's economy along with a thriving winter and seasonal tourist trade.

POLITICAL STRUCTURE

Pima County contains two incorporated cities (Tucson and South Tucson) and two incorporated towns (Oro Valley and Marana)--see Figure 14. The Pima Association of Governments (PAG) serves as the regional planning agency. It was chartered in 1970 by the state and serves as a coordinating agency for regional plans.

The U.S. Army Corps of Engineers is also involved in regional planning efforts. The Tucson area is currently (1979) the subject of an Urban Study, which addresses problems of flooding and other water related problems such as water mining and future water supplies, land subsidence, water quality and water reuse (U.S. Army Corps of Engineers, 1978). It will also be a major beneficiary of the Central Arizona Project.

Concerning water, the political structure involves a range of interests from the individual to the Federal government. The municipalities are responsible for water supply and the city of Tucson is the primary focus of this study. Wastewater was separately managed by the city and county before 1979 but is now dealt with jointly under the City/County Sewer merger.

The U.S. Army Corps of Engineers (1978) reports that "There is presently no organization or authority in the study area which has regional control over water quality, water supply, regional water supply systems, and regional wastewater management systems. Current management practices call for separate control of small portions of the water supply, use, and wastewater generation systems in the region."

Water quality standards are the responsibility of the Arizona Water Quality Control Council, and the overall responsibility for monitoring Pima County's 208 Program (designed to reduce pollutants from all sources) lies with the Governor's Office. Other involved agencies are the Office of Economic Planning and Development, the Arizona Department of Health Services, the Arizona Water Quality Control Council, the Governor's Advisory Council on Intergovernmental Relations and the State Planning and Coordinating Committee.

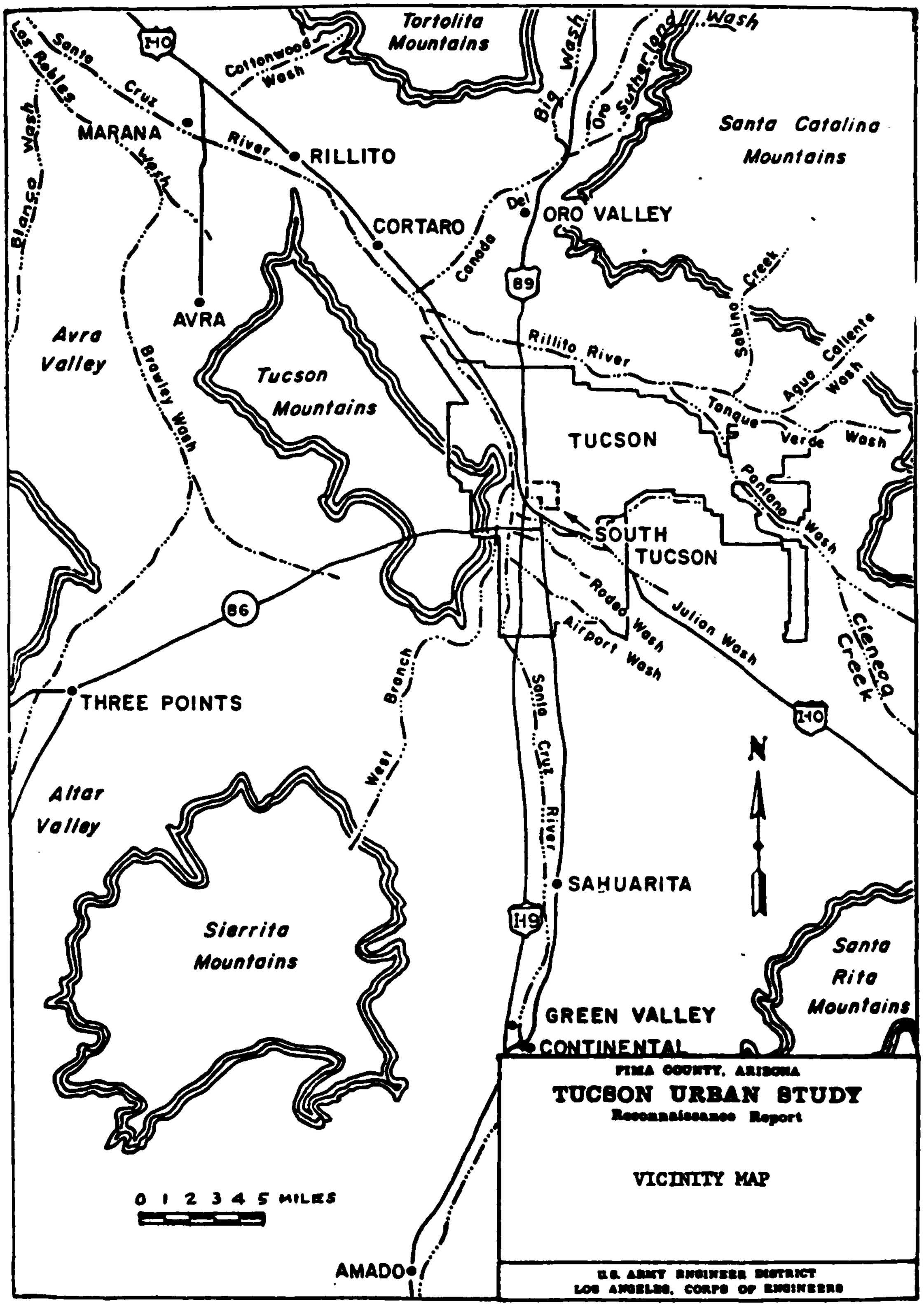
PHYSICAL CHARACTERISTICS

Topography

Tucson is located within the Sonoran Desert in a physiographic zone known as the Basin and Range Province. This region is characterized by

FIGURE 14

TUCSON VICINITY MAP



roughly parallel and discontinuous mountain ranges separated by continuous basins. Tucson lies within a relatively flat basin which slopes gently toward the northwest. The city is situated along the Santa Cruz River (now a dry wash for most of the year), one of the tributaries of the Gila River. The alluvial valley is composed of tertiary and quaternary gravel, sand, silt and clay to thicknesses which exceed 5,000 feet in places (U.S. Army Corps of Engineers, 1978). Most of the area's water supply is found within these deposits.

The Santa Cruz River flows northward from Tucson where it joins the Gila River just southwest of Phoenix, Arizona. Another tributary of the Gila River, the San Pedro River, is located in the northeast corner of the Corps' study region. It also flows northward and joins the Gila near Hayden, Arizona. In addition to the Santa Cruz and the San Pedro rivers, the area is dissected by numerous major and minor washes. The Santa Cruz River and some of the major washes can be seen in Figure 14.

The combination of arid soils, sloped topography, and intensive rainstorms make this region susceptible to frequent flash flooding.

Climate

Tucson is characterized by low rainfall and intense heat. Topographic variations can result in varied climates as average temperatures drop approximately 4°F for every 1,000 foot increase in elevation. This elevation gradient is also reflected in the growing season. Tucson has 250 frost free days while a site 1,000 feet higher in elevation would lose approximately 30 frost free days (Dunbier, 1968). Rainfall also increases four to five inches annually with each 1,000 foot increment (U.S. Army Corps of Engineers, 1978). The city itself receives less than 15 inches of precipitation per year.

The rainfall arrives in two seasons. The winter season is from November to March and is a result of the Pacific subtropical highs. Approximately 23 percent of the year's precipitation is delivered by these storm systems which are slow moving, widespread, and relatively gentle. Snowfall is rare in the Tucson Basin but approximately 75 inches per year are reported in the higher reaches of the nearby Catalina Mountains (U.S. Army Corps of Engineers, 1978).

The summer rainy season, caused by the Gulf tropical air usually begins in July and lasts until September. The summer storms are intensive, localized thunderstorms and give rise to flash floods.

The lowest monthly average temperature is approximately 50°F and occurs in January. The average July temperature is about 85°F with a low relative humidity. The Sonoran Desert averages approximately 30 percent humidity during the summer (Dunbier, 1968). The diurnal temperature range is greater in the early summer than in the winter.

Vegetation

The vegetation of the Tucson region reflects its desert environment. The deep arid soils of the basin floors support growth of the mesquite/

saltbush community which grows in and along stream channels. Creosote bush/bursage shrubland predominates the land surface away from the streams and paloverde/cactus shrubland is common at the higher altitudes. In general, this desert vegetation draws far less water from the area's hydrologic budget than does vegetation in temperate climates.

Other Physical Resources

More than half of the nation's copper production comes from Arizona; and Pima County is the leading copper producer in Arizona. Six major copper mines operate in the Tucson area making copper extraction the dominant mining activity in the region. These copper mines are expected to continue production (given a relatively stable market) for at least 35 more years (U.S. Army Corps of Engineers, 1978).

The Santa Cruz-San Pedro basins contain other mineral resources in addition to copper. These resources include sand and gravel, molybdenum, gold, stone, silver, zinc, lime, and gypsum.

Sand and gravel deposits are found among the major washes and their extraction results in a reduction of the groundwater recharge capability. This in turn causes erosion and siltation problems along the river channel.

DEMOGRAPHY

With a population growth rate of nearly 5 percent per annum between 1970 and 1975, Arizona experienced one of the most dramatic population increases in the nation. In absolute terms, the state population rose from 1,770,990 to 2,208,000 in 1975, of which Pima County contributed 449,554. With 20.2 percent of the state's population, Pima County is the second largest population agglomeration in the state after Maricopa County. Table 57 provides a summary of population changes (by jurisdiction) in the county between 1970 and 1975; the dominance of the city of Tucson is particularly noteworthy.

Population Projections

Table 58 illustrates an array of population projections for Pima County up to the year 2000. Due to the rapid economic growth and the consequent increase in employment levels, and due to uncertainty about how long this growth will be sustained and at what levels, the population projections exhibit wide disparities. For the year 2000 the lowest estimate from the six sources is 583,290 (beginning with a base 1975 population of 403,135) and the highest is 879,300. Given the wide levels of variance in these estimates, the projections must be treated with caution. Throughout, we will use the projections approved by the Pima Association of Governments (PAG-208, 1977). These suggest a low estimate of 675,009 and a high estimate of 879,319 (Figure 15)--a projected population increase of 67 to 118 percent over the 1975 total.

TABLE 57

POPULATION CHANGES FOR PIMA COUNTY: 1970-1975

Area	Area Population 1970	1975	Difference
Eastern Pima County			
City of Tucson	262,933	298,683	35,750
City of South Tucson	6,220	6,218	2
Oro Valley	581	1,168	587
Other unincorporated areas	70,205	130,785	60,570
Eastern Pima County Total	339,949	436,854	96,905
Tucson urban area	294,184		
Western Pima County and San Xavier	11,718	12,690	972
Total Pima County	351,667	449,544	97,877

Source: Pima Association of Governments, Water Quality Planning, PAG-208 Population Report, April, 1977.

TABLE 58

POPULATION PROJECTIONS FOR PIMA COUNTY: 1975-2000

Projection Source	1975	1980	1985	1990	1995	2000
Arizona Department of Economic Security[1]:	452,000	519,00	582,800	644,800	702,700	751,600
Arizona Economic Information Center[2]:						
Low	460,000	490,000	520,000	570,000	630,000	690,000
High	475,000	550,000	620,000	700,000	780,000	850,000
Arizona Office of Economic Planning and Development[3]:						
Low	448,661	450,139	485,931	518,311	555,890	591,063
High	448,799	474,473	566,198	632,585	730,459	816,989
CPP[4]:						
Low	N/A	476,700	526,400	582,500	632,700	675,000
High	N/A	515,100	594,200	687,100	786,000	879,300
Hernandez *et al*[5]:						
Low	403,135	453,797	499,065	535,572	563,025	583,290
High	405,052	468,664	556,715	641,724	713,473	788,950
Tucson Gas & Electric[6]:	444,000	499,000	476,000	666,000	769,000	N/A

Source: Pima Association of Governments, Water Quality Planning, PAG-208 Population Report, 28, April 1977.

[1] "Poplation Estimates of Arizona as of July 1, 1974," Report No. 6, Arizona Department of Economic Security.

[2] Projection for eastern Pima County only.

[3] OEPAD EDPM model (Economic/Demographic Projection Model), June 1976 (year 2000 listed actually as 1999).

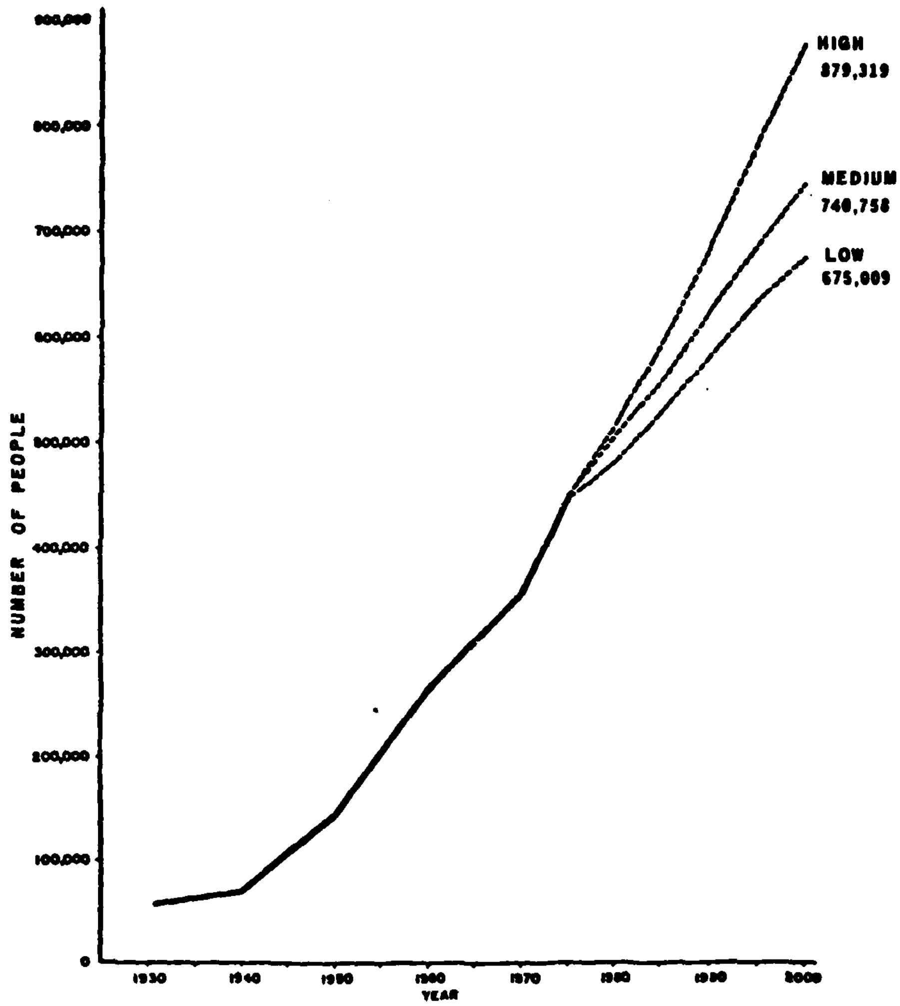
[4] CPP--*Long Range Population Forecasting for the Tucson SMSA with a Disaggregated Econometric Model of the Population Employment Variety*, Dept. of Business and Economic Research, University of Arizona, Tucson, 1976.

[5] Hernandez, Jose, and others, "Toward the Year 2000: How Fast is Tucson's Population Growing?" *Arizona Review*, Vol. 21, No. 809, August-September, 1972.

[6] "Demand and Energy Forecast, 1976-1995," Tucson Gas & Electric Company (unpublished document).

FIGURE 15

HISTORIC AND PROJECTED POPULATION, PIMA COUNTY, ARIZONA



Source: Pima Association of Governments Water Quality Planning PAG-208 Population Report 28 April 1977

households are officially retired. Employment projections are therefore of crucial supplementary importance in using population projections, and Table 60 presents a set of employment projections compiled by the U.S. Army Corps of Engineers.

Income

With rapid population and economic growth in the area, personal income has also grown quickly. Since 1970, total personal income has increased by 78 percent, mainly reflecting population growth. Per capita income has grown by some 40 percent, compared with 52 percent in the entire United States between 1970 and 1976. But this increase in income has been unevenly distributed. The average per capita income in 1975 was $5,090 and 60 percent of Tucson households earned over $10,000, but on the Papago Indian reservation, the 1973 per capita income amounted to only $807.

Housing

Although affected less than many other parts of the country, Tucson experienced a considerable decrease in new housing starts as a result of the 1973-76 recession. When the industry recovered in 1976-1978, there was a renewed emphasis on multiple dwelling units rather than the construction of traditional single-family homes. Along with declining vacancy rates, this trend has been interpreted as a sign of coming prosperity in the housing industry (U.S. Army Corps of Engineers, 1978). But by the summer of 1979 it seemed likely that this recovery would be temporary. The impending recession is expected to diminish the level of new starts into the early eighties.

Tucson's housing stock is relatively new with 44 percent of all homes being purchased new; the average age of owner occupied homes is only 12 years. There was a total of 84,226 occupied units in 1970 with an average occupancy of 3.1 persons per unit (U.S. Bureau of The Census, 1973). Homeowners comprise 71 percent of the city's households, and the median value of their homes if $28,995. Their median income is $13,795. The renter population amounts to 29 percent of Tucson households, and seems to be split into an affluent group renting single family homes and luxury apartments and a poorer group renting a variety of types of accommodation. Only eight percent of the renter households have an annual income of less than $15,000 (U.S. Army Corps of Engineers, 1978).

As with other resources, the Papago Indians on the nearby reservation experience the worst housing conditions.

Education

Twenty-five percent of Tucson residents over 25 years of age have a college degree, compared with 10.7 percent for the entire United States; 21 percent have less than a high school education, compared with 28.5 percent for the United States. Tucson's population is, on the average, well educated, but levels of education are very unevenly distributed through the population.

TABLE 59

PERCENT OF EMPLOYMENT BY SECTOR FOR PIMA COUNTY
(ANNUAL AVERAGE EMPLOYMENT)

Sector	1956	1960	1965	1970	1975
Agriculture	4.5	2.6	1.4	1.6	1.0
Mining	3.1	3.5	3.7	5.5	5.0
Construction	6.9	8.3	6.0	7.2	6.0
Manufacturing	14.2	10.1	6.9	7.7	7.7
Transportation Communication Utilities	7.7	6.2	5.7	5.0	5.0
Trade	17.8	18.9	19.0	20.1	20.4
Finance, Insurance and Real Estate	2.7	3.5	4.0	4.3	3.9
Services	12.0	14.6	15.1	16.4	18.1
Government	15.2	17.9	23.1	22.8	26.2
Other	15.9	14.4	15.1	9.4	6.7
Total	100.0	100.0	100.0	100.0	100.0

Source: U.S. Army Corps of Engineers (1978).

TABLE 60

PROJECTED EMPLOYMENT ESTIMATES[1]

Activity	1980				1990				2000			
	Low		High		Low		High		Low		High	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Agriculture	1.5	0.8	1.5	0.8	1.3	0.5	1.3	0.5	1.2	0.4	1.0	0.3
Mining & Quarrying	9.5	5.2	9.5	5.1	10.8	4.5	10.8	4.2	12.0	4.0	12.0	3.6
Contract Construction	12.0	6.5	12.2	6.5	14.7	6.1	15.9	6.2	17.6	5.8	19.8	5.9
Manufacturing	15.1	8.2	15.6	8.3	19.8	8.2	21.7	8.5	24.0	5.9	28.0	8.4
Trans., Comm., P.U.	10.9	5.9	11.1	5.9	14.2	5.9	15.1	5.9	17.9	5.9	19.8	5.9
Trade	38.6	21.0	39.4	21.0	50.7	21.0	53.8	21.0	63.7	21.0	70.4	21.0
Finance, Insurance, Real Estate	10.9	5.9	11.1	5.9	15.2	6.3	16.2	6.3	19.7	6.5	21.8	6.5
Services	38.6	21.0	39.4	21.0	58.0	24.0	61.3	23.9	80.3	26.5	80.0	26.3
Government/ Civilian	46.9	25.5	47.9	25.5	56.7	23.5	60.3	23.5	66.7	22.0	74.0	22.1
Total	184.0	100.0	187.7	100.0	241.4	100.0	256.4	100.0	303.1	100.0	336.0	100.0

[1]Self-employed individuals, domestic employees, and unpaid family workers are included and allocated to sectors. The allocation was based upon data from the Bureau of the Census and the Department of Economic Security for the year 1970.

Source: U.S. Army Corps of Engineers (1978)

Racial Composition

Table 61 gives estimates of ethnic origin compiled by the Arizona Department of Economic Security and based on 1973 report by the U.S. Bureau of the Census.

LAND USE

Pima County covers a total land area of 5,914,240 acres. The Papago Indian Reservation accounts for 42 percent of the county's land, and a further 44 percent is owned by the state of Arizona and the Federal government. Table 62 gives statistics on land ownership and land use. It can be seen that 86.4 percent of the county's land is classed as "Rural and Indian Reservations." Of the remainder, agriculture and ranching are the major uses (Table 63).

As would be expected, the eastern part of the Pima County--dominated by the City of Tucson--displays a very different pattern of land use from the county as a whole. Residential, commercial and industrial uses predominate. Of particular importance is Tucson's dramatic growth rate. In 1972, Tucson covered 82,500 acres having grown 224 percent from its 1950 acreage of 25,500. urban land uses have been rapidly displacing agriculture land use in the area.

This changing pattern of land use is crucial to any consideration of water use and conservation in the area. Land use projections for the area all emphasize a reduction in agricultural acreage. According to a University of Arizona study in 1972, "agricultural use will diminish as more land is converted to residential areas" (Matlock and Davis, 1972). More recently, a study by the Pima Association of Governments has attempted to project changes in agricultural acreage to the year 2000 (see Figure 16). Defining the Tucson metropolitan region as consisting of the Upper and Lower Santa Cruz valleys and the Avra and Altar valleys, the PAG study estimated that cropped agricultural acreage would diminish from 54,500 acres in 1975 to 10,600 in the year 2000. For the city of Tucson itself, it is estimated that cropped acreage will drop from the present 2,600 acres to 700 acres by the year 2000 (PAG 208, Projected Water Use and Water Budget Calculations for Pima County, Arizona, 1978).

WATER RESOURCES

Water Supply

In 1870, the inhabitants of Tucson drew their water from individual shallow wells or from a horse-drawn wagon selling water by the bucket. In 1880, the Territorial Sheriff was issued the first water franchise and formed a company that supplied the city with Santa Cruz water. The franchise was taken over by the city in 1900, and after 1920 the city began developing groundwater sources. With rapid growth in the 30s and

TABLE 61

ETHNIC ORIGIN OF THE EASTERN PIMA COUNTY POPULATION

Ethnic Origin	Number	Percent	Percent of United States
European	301,000	70	81.4
Mexican American	104,000	24	5.0
Black	12,400	3	12.0
Native American	10,600	2	0.4
Other	3,200	1	1.2

Source: Arizona Department of Economic Security, 1973.

TABLE 62

LAND OWNERSHIP IN PIMA COUNTY: 1972

Classification	Acres	Percent of Total Area
Federal lands	1,548,608	26.18
National forests	(348,800)	
Bureau of Land Management	(304,000)	
Other federal lands	(896,608)	
State of Arizona	1,033,600	17.48
Papago Indian Reservation	2,509,760	42.43
Private	720,384	12.18
Municipalities and other	101,888	1.73
Total	5,914,240	100.00

Source: Pima County Planning Department

TABLE 63

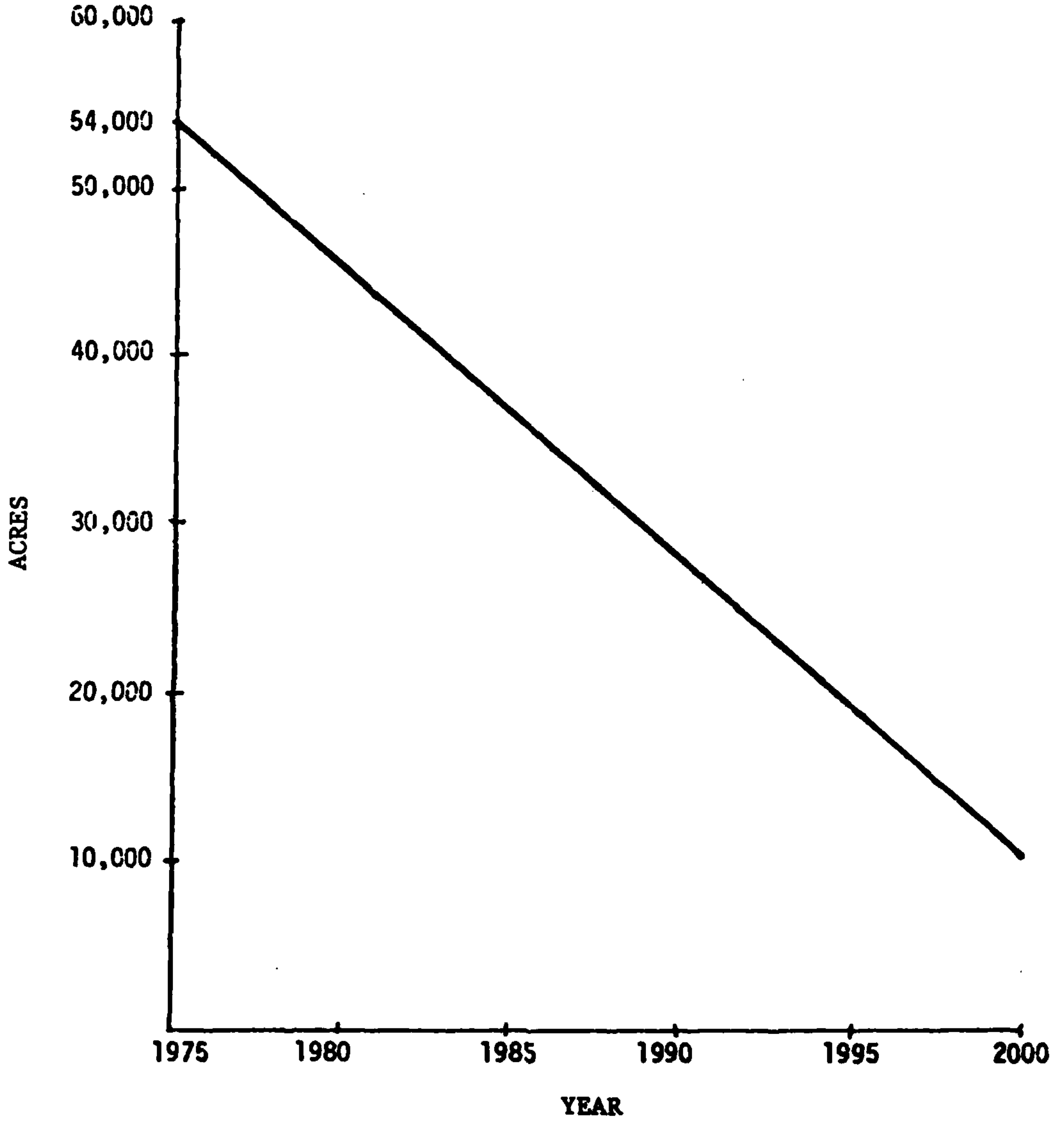
LAND USE IN PIMA COUNTY: 1972

Classification	Acres	Percent of Total Area
Rural and Indian Reservation	5,111,559	86.44
Urban	(93,713)	1.59
Residential	(19,363)	
Commercial	(7,949)	
Industrial	(1,711)	
Public and quasi-public	(64,685)	
Agricultural	380,456	6.43
Grazing and ranching	243,609	4.13
Mining	55,655	0.94
Mountainous lands	29,248	0.05
Total	5,914,240	100.0

Source: Bureau of Land Management, Coronado National Forest, Department of Property Valuation, State Land Department.

FIGURE 16

PROJECTED AGRICULTURAL ACRES: 2000



Source: Pima Association of Governments, 208 Land Use Projections (1978).

after World War II, private water companies flourished, but today many of these have been purchased by the city, making the city's system by far the largest supplier.

Surface Water

The annual average precipitation in the Tucson Basin varies from six to thirty inches with averages between twelve and sixteen inches over much of the area. Most precipitation arrives during low frequency, high volume events, when surface runoff is substantial. Approximately 50-55 percent of the total annual precipitation falls in the three months from July to September. Given the high monthly average temperatures in the region, there is also a high rate of evapotranspiration and evaporation throughout the year. Table 64 gives an overview of the water budget for Pima County, and its four major hydrologic basins. In each area, only 2.0-4.5 percent of the water recharges the aquifer system, some of which is lost by underflow; the remaining 96-98 percent "is lost or consumed by evaporation, evapotranspiration, wildlife uses, and surface flows out of the county," (PAG 208, Water Conservation Strategies, 1978).

The Tucson Basin, with the city of Tucson at the center, is mainly contained in Area III--the Santa Cruz Valley. The Santa Cruz is the largest river basin in Arizona south of the Gila River, covering some 5-1/2 million acres of which 256,000 are in northern Mexico. Streamflow in the Santa Cruz is sporadic and unreliable despite the basin's size. In their Tucson Urban Study (1978), the U.S. Army Corps of Engineers estimate that, in the vicinity of Tucson, the river is "generally dry at least 320 days per year. For a 20-year recurrence interval, the number of days of no flow in any one year for the Santa Cruz River would exceed 345 days." In the tributaries to the main stream, flow is generally even more irregular.

Groundwater

Due to differences in land use, the Tucson Basin experiences a higher level of surface water infiltration and acquifer recharge than the remainder of the county. Figure 17 provides a diagram of the basin's water budget. Given the high levels of evaporation and unreliability of surface flows, it is not surprising that Tucson relies entirely on groundwater sources for its water supply. Resource depletion has become a serious problem, however, as rapidly increased consumption has caused the water table to drop an average of four feet per year over the past 25 years (Barr and Pingry, 1976). Table 65 shows the growth in water usage for the Tucson Basin between 1950 and 1975. This water is supplied from private as well as publicly operated wells throughout the basin. The current overdraft rate for eastern Pima County is approximately 3.34/1 (U.S. Army Corps of Engineers, 1978).

The Tucson Water and Sewer Department operates approximately 300 wells and supplies the city's municipal, domestic, and much of its industrial water needs. The entire water supply comes from four well fields: the Interior, Avra Valley, Southside, and Santa Cruz fields. Their location with respect to the city is shown on Figure 18. Other river basins, such as the Altar Valley to the West and the San Pedro to

TABLE 64

PIMA COUNTY ANNUAL WATER GENERATION

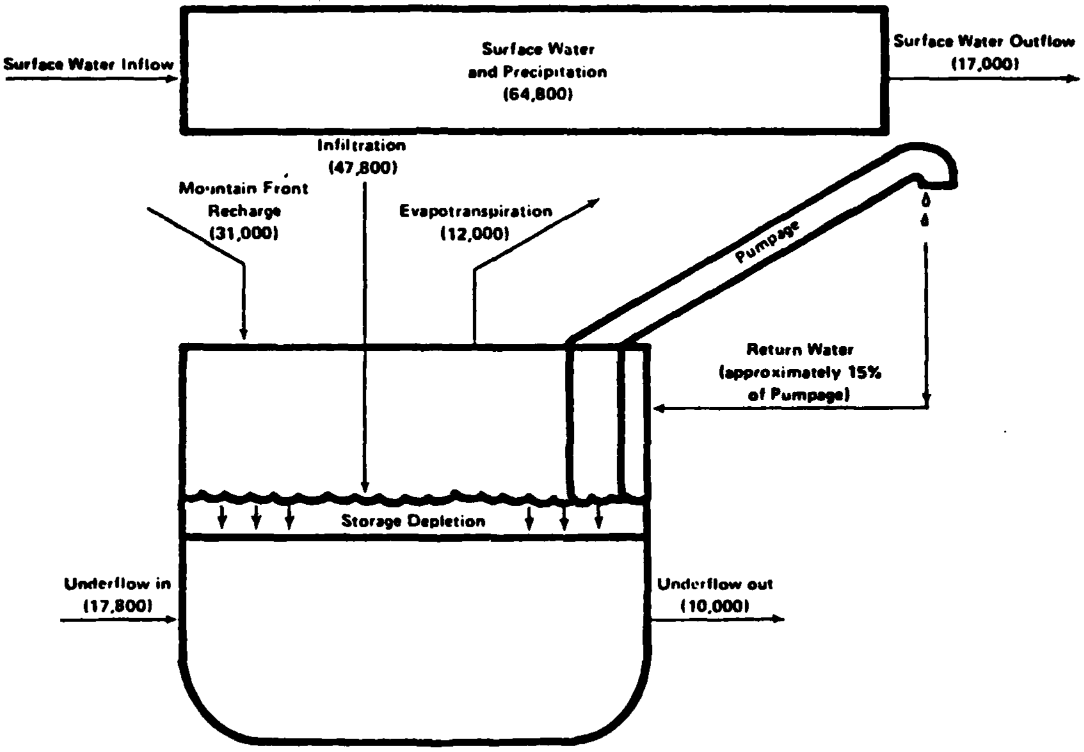
	Area (SQ. MILES)	Precipitation (INCHES)	Surface Area (PER YEAR)	Amount Recharged (ACRE-FEET)	(PERCENT)	Amount Remaining (ACRE-FEET
Ajo Area	358	9.10	173,800	4,000	2.30	169,800
Avra/Alter Valleys	1,050	14.00	784,100	15,000	1.91	769,100
Santa Cruz	2,050[1]	16.11	1,761,600	100,000	4.54	1,681,600
Lower San Pedro	285[2]	16.80	255,400	7,000	2.74	248,400
Total	3,743	14.91[3]	3,000,000	126,000	4.20	2,870,000

Source: Pima Association of Governments, 208, Water Conservation Strategies, 1978.

[1]Includes 438 square miles in the Coronado National Forest
[2]Includes 115 square miles in the Coronado National Forest
[3]Weighted averages

FIGURE 17

NATURAL RECHARGE AND THE WATER BUDGET BALANCE FOR THE TUCSON BASIN



Figures represent USGS annual estimates based on average data for the period 1936-1963, in acre feet (AF).

Source: Barr and Pingry (1976)

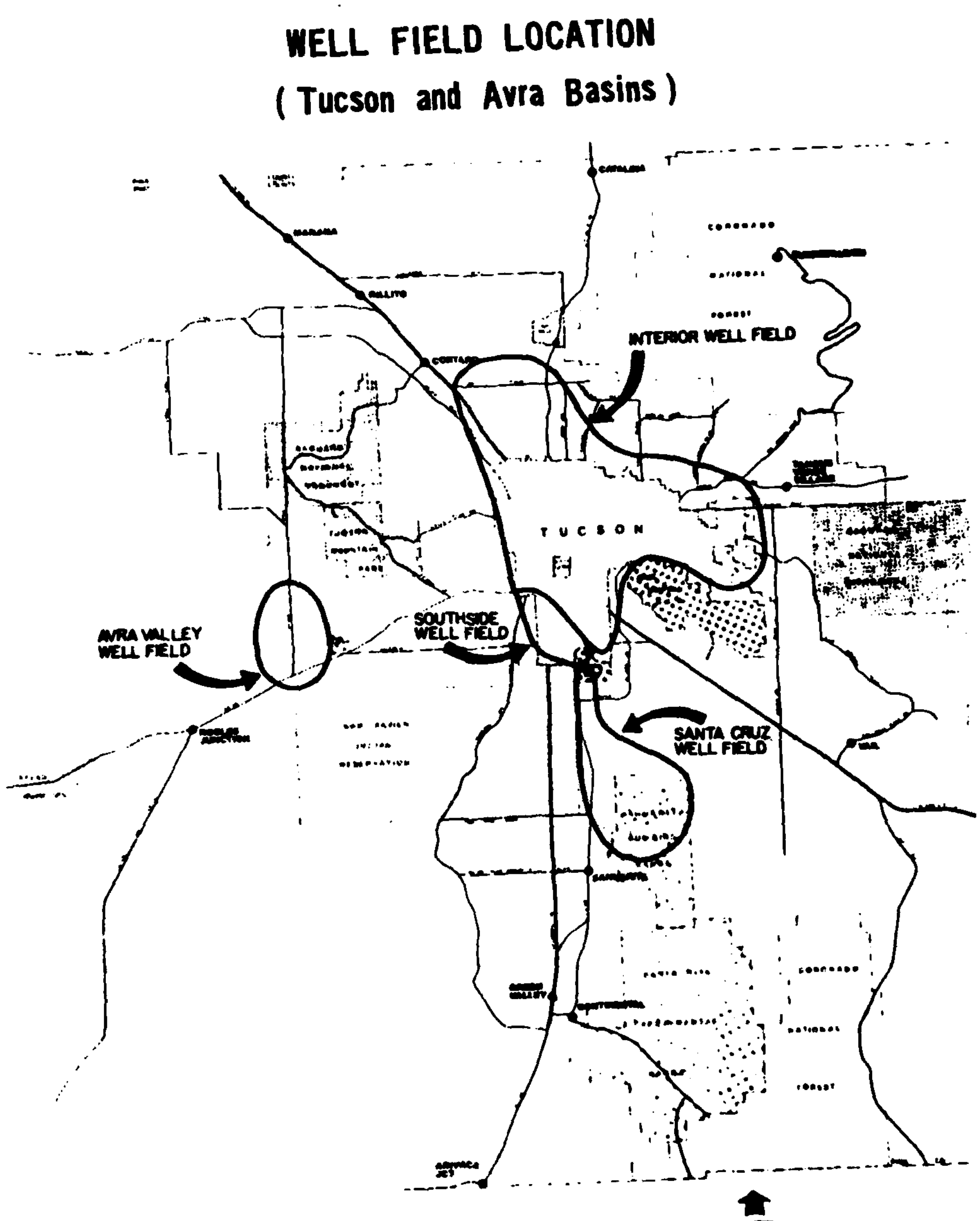
TABLE 65

GROUNDWATER PUMPAGE BY USER TYPE IN THE TUCSON BASIN
1950-1975 (ACRE FEET IN 1,000'S)

Year	Agriculture	Municipal and Domestic	Industrial	Total
1950	99.9	20.2	4.9	125.0
1951	118.7	20.3	5.0	144.0
1952	133.2	21.5	5.3	160.0
1953	135.1	22.8	6.1	164.0
1954	140.7	23.1	6.2	170.0
1955	134.6	23.9	6.5	165.0
1956	124.5	28.1	7.4	160.0
1957	110.9	31.8	7.3	150.0
1958	99.2	37.5	7.6	144.3
1959	93.2	40.9	9.6	143.7
1960	74.1	51.2	10.1	135.4
1961	75.7	53.2	13.0	141.9
1962	100.6	54.4	15.8	170.8
1963	93.2	55.5	17.3	164.0
1964	86.5	55.1	17.5	159.1
1965	104.1	54.2	18.4	176.7
1966	93.7	53.9	17.7	165.3
1967	81.3	62.7	20.0	164.0
1968	85.0	66.8	30.7	182.5
1969	102.6	71.4	34.9	208.9
1970	88.1	71.5	51.1	210.7
1971	83.6	75.0	52.3	224.0
1972	71.1	87.4	58.7	217.2
1973	78.2	101.5	60.2	239.9
1974	86.6	98.8	60.6	246.0
1975	110.1	97.3	62.0	269.4

Source: U.S.G.S. unpublished estimates, Water Resources Division, Tucson, Arizona, and Davidson, op. cit., p. C29.

FIGURE 18



Source: Johnson (1978)

the northeast, do not currently supply Tucson with groundwater but may be used in the future.

The Interior Well Field, corresponding closely to the city's municipal boundaries, is the major supplier for the city (Figure 18). It provides 60 percent of the city's water (Johnson, 1978). Although some of the 200 wells in this field are of modern design and constructed by the city utility, most are older and were acquired in the period after World War II from private water companies. Figure 19a shows the production capacity of the Interior Well Field from 1968 to 1977. Overall capacity has increased marginally during that ten-year period, mostly due to the purchase of private companies by the utility. But according to the Acting Chief Hydrologist for the city's Water and Sewer Department, "there are few remaining water companies whose inclusion into our system would significantly increase our supply. Replacement drilling sites in favorable hydrologic areas within the interior well field area which have the same expectation of success as those in the past are becoming harder to locate" (Johnson, 1978).

The Avra Valley Field is about fifteen miles west of the city and with its 16 operational wells supplies 15 percent of the water pumped to the city. The water is pumped into the city's distribution system via the Martin Reservoir. This well field's capacity (Figure 19b) has increased from just over 5,000 gpm in 1969 to 14,000 gpm in 1977 and has the potential to increase further. To increase its supply from the Avra field, however, the city must purchase land which was formerly is agricultural use; having done so, the city is legally restricted to pumping a maximum of 2 acre feet per acre per year.

The Southside Field is on the southern edge of the city, in the Santa Cruz Basin, and supplies 5 percent of the city's water from 13 wells. This field has the dual advantage of lying uphill from the city, therefore allowing the water to flow by gravity, and of receiving groundwater recharge due to runoff into and from the Santa Cruz River. Nonetheless, this field's capacity has dropped over 40 percent between 1968 and 1977 (Figure 19c) as the water table has fallen between 4 and 8 feet per year. "The density of wells located in this area precludes additional new well construction to increase the supply" (Johnson, 1978).

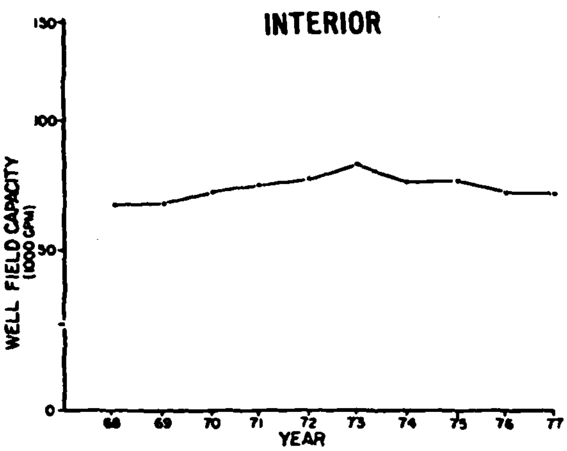
The Santa Cruz Well Field (Figure 19d) also lies to the south of the city, and with 26 wells, supplies about 20 percent of the utility's water. Like the neighboring Southside Field, the Santa Cruz Field lies physiographically and hydrologically uphill from Tucson, but here too, competition for water has been intense. Like the Avra Valley, the Santa Cruz Field has been the subject of considerable litigation, clouding its future potential as a major supplier of water to Tucson. This field has experienced the largest absolute reduction in capacity since 1968 (over 9,000 gpm), despite the fact that six new wells were added in 1975.

Projected Future Supply

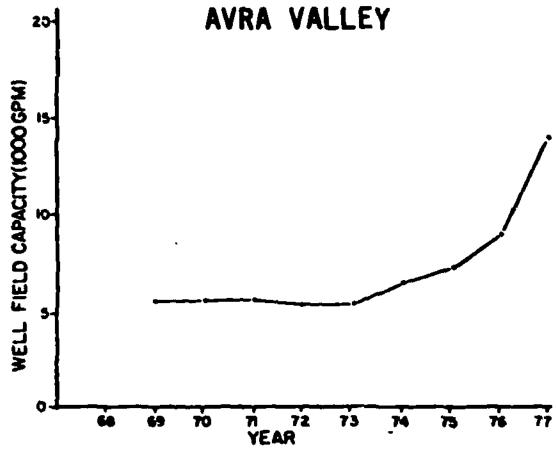
The aquifer beneath the Tucson Basin may be as deep as 2000 feet, but Tucson hydrologists estimate that water below 1200 feet cannot feasibly be recovered. This was concluded for physical as well as

FIGURE 19

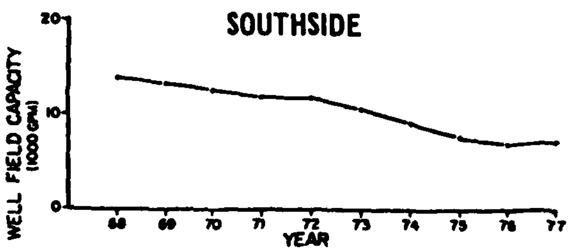
WELL FIELD CAPACITY, 1968-1977



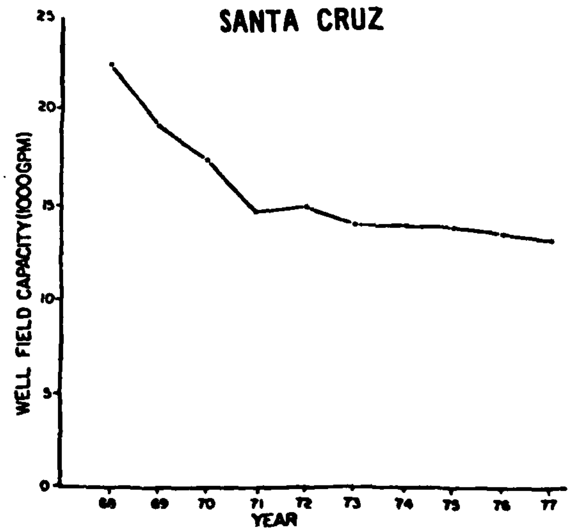
(a)



(b)



(c)



(d)

Source: Johnson (1978)

economic reasons (Tucson Metropolitan Utilities Management Agency [MUM], 1976). Table 66 provides a current water supply overview with estimates of the total recoverable groundwater to a depth of 700 feet and to a depth of 1200 feet. From these PAG estimates (Water Resources Summary, 1978) there would seem to be approximately 37-1/2 million acre-feet of recoverable groundwater down to 700 feet and 67 million acre-feet down to 1200 feet.

In 1975, 269,400 acre-feet of groundwater was pumped to the Tucson Basin, and during the 1970s, this figure was growing at the rate of 5.7 percent annually (see Table 65). With this rate of pumpage, it has been estimated that the basin aquifer suffered a net depletion in 1975 of 150,000 acre-feet (Barr and Pingry, 1976). Johnson has determined the effect of this aquifer depletion on the water table, suggesting that, in the last thirty years, the four well fields supplying Tucson have all experienced a fall in the water table of over one hundred feet (Figure 20). Over the last six years, according to municipal utility hydrologists, the lowering of the water table has accelerated from an average of four feet per year to between six and ten feet per year (MUM Staff Hydrologists Report, 1976). The present water table is thought to lie between 250 and 300 feet below the surface (Barr and Pingry, 1976).

Future water supply to the Tucson region may come from one or more of the following three possibilities: the development of existing sources, the exploration and development of new groundwater sources; the development of non-groundwater sources.

Existing Sources: Johnson (1978) makes clear that the Interior, Southside and Santa Cruz well fields are unlikely to support increased well capacity. In the Interior Field, most if not all of the favorable hydrological resources are already being fully exploited, and in the Southside Field the density of present wells precludes further construction. In the Santa Cruz Field, Johnson pinpoints competition from private wells as the reason behind the decreased capacity of the utility's wells. This competition is likely to become more, rather than less, intense.

Only in the Avra Valley outside the Tucson Basin is there any reasonable expectation that production capacities might increase significantly. Indeed, "it is the increased production capability which has" in the last ten years "replaced the losses incurred in the Southside and Santa Cruz well fields" (Johnson, 1976). But there are problems here too--of a legal rather than a physical nature. The well field is clearly capable of supplying more water, but the city of Tucson is prevented by a series of Arizona Supreme Court rulings from drawing more than 2.0 acre-feet per acre per year from the land it owns in the valley. Further, the city can expand the acreage of land it owns only by purchasing land that was historically using water for agricultural purposes.

New Groundwater Sources: Enacted first in 1948, legal restrictions on the city's ability to expand its well development in irrigated land do not apply to the Altar Valley and the San Pedro Basin. Unlike the rest of the region, these areas have not been declared critical groundwater

TABLE 66

WATER SUPPLY OVERVIEW
(ACRE-FEET)

Area	Natural Average Annual Long-Term Recharge	Total Normalized Recoverable Groundwater		Applied Federal Land Factor		Recoverable Groundwater Estimates	
		In Storage To 700 ft.	In Storage To 1200 ft.	To 700 ft.	To 1200 ft.	To 700 ft.	To 1200 ft.
Ajo Area	4,000[1]	No estimate	No estimate	-	-	No estimate	No estimate
Avra Valley	4,000[4]	7,700,000[3]	13,400,000[2]	614,000	1,300,000	7,100,000	12,100,000
Altar Valley	11,000[1]	6,700,000[5]	17,800,000[1]	51,000	300,000	6,600,000	17,500,000
Upper and Lower Santa Cruz Area	100,000[2]	24,000,000[6]	45,200,000[2]	4,600,000	7,800,000	19,400,000	37,400,000
Lower San Pedro Area	7,000[1]	4,500,000[1]	-	-	-	4,500,000	-

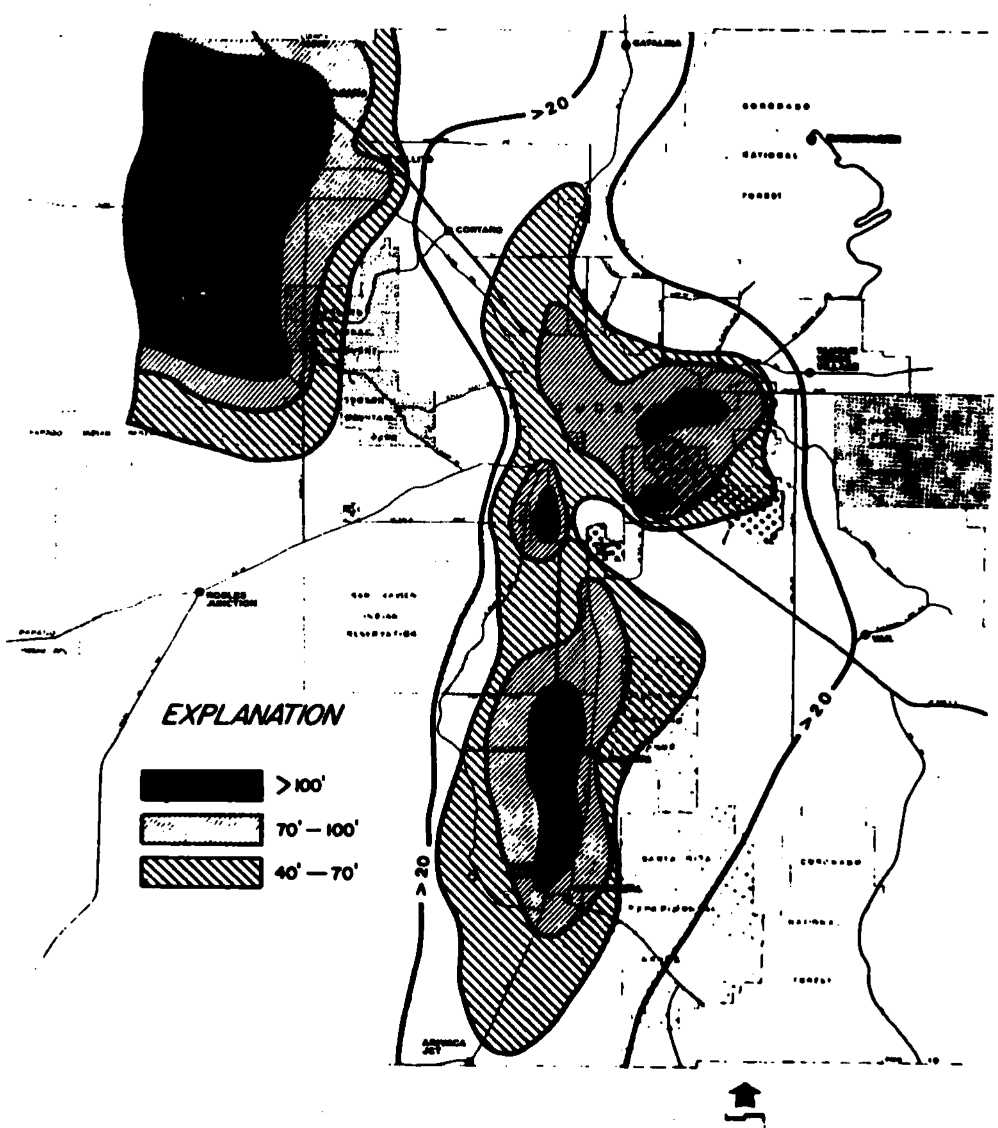
1 - Only one estimate available and there are no other estimates to show either support or non-support for the estimate.
2 - Two independent sources of information whose estimates are within ± 10% of the given value after the appropriate time and/or area factors have been applied.
3 - Three independent sources of information whose estimates are within ± 5% of the given value after the appropriate time and/or area factors have been applied.
4 - Represents average of three independent estimates.
5 - Two independent sources of information whose estimates are within ± 25% of the given value after the appropriate and/or area factors have been applied.
6 - Three independent sources of information whose estimates are within ± 15% of the given value after the appropriate time and/or area factors have been applied.

Source: Pima Association of Governments, 208 Water Resources Summary, 1978

FIGURE 20

WATER TABLE DECLINE

Avra–Altar Valleys: 1952–1977 (25 Years)
Tucson Basin: 1947–1977 (30 Years)



Source: Johnson (1978)

basins. The Altar Valley lies some thirty miles to the southwest of Tucson, south of the Avra Valley and, as Table 66 shows, it contains an estimated recoverable groundwater supply of 6.6 million acre-feet to a depth of 700 feet.

The San Pedro River is second only to the Santa Cruz in size, but like the Santa Cruz it is dry for most of the year. It cuts through the extreme northeastern corner of Pima County, and in its lower reaches has an estimated recoverable groundwater supply of 4.5 million acre-feet down to 700 feet.

New Non-Groundwater Sources: According to a 1963 U.S. Supreme Court decision which ended nearly 40 years of political and legal wrangling, Arizona won the right to withdraw 2.8 million acre-feet from the Colorado River each year. This decision enabled Arizona to proceed with the Federally-planned Central Arizona Project (CAP) which would supply Colorado River water to the relatively heavily populated areas of central and southern Arizona.

Construction is currently underway on the northern portion of the project, from the Colorado River to Phoenix, but the Phoenix to Tucson portion is still in the planning stage. The design of this portion is scheduled for completion in 1982 with construction due in 1982-86. First delivery of water to Tucson is planned for 1987. Although final allocations have not yet been made, it is estimated that initially 54,000 acre feet will be delivered to the Tucson region for municipal, agricultural, and non-mining industrial uses. This annual quantity will increase to about 98,000 acre-feet by the year 2034. The remainder of the county should receive an additional annual quantity of 55,000 acre-feet from the CAP project. This water is earmarked for the mining industry (PAG, Water Resources Summary).

There are important restrictions on the use of CAP water, however, reflecting the political heritage of the project. According to Barbera (1978), "the CAP was conceived of and thought of as a rescue project designed to aid threatened agricultural groups in Arizona." Thus, "water delivered from the Project may only be used on lands with a recent history of irrigation. Also, groundwater pumping for irrigation in the contractors' service area must be reduced by an amount equal to the quantity of Project water delivered that year" (U.S. Army Corps of Engineers, 1978). As agriculture has been displaced by urban development, so have plans for use of CAP water focused increasingly on municipal and industrial uses.

Water Quality and Treatment

Water quality has been the subject of considerable Federal legislation during the present decade and is no longer viewed as secondary in importance to water quality. Except for drinking water, the state of Arizona has full responsibility for setting water quality standards. Its Office of Water Quality Control has not yet established standards for groundwater, but is currently attempting to develop such a program.

Most groundwater, in the Tucson Basin meets both the mandatory and chemical quality limits for drinking water (U.S. Army Corps of Engineers, 1978). In some places undesirable concentrations of dissolved solids, particularly fluoride and nitrates are found. Water containing more than 1,000 mg/l (milligrams per litre) total dissolved solids is not used for drinking water. Water with more than this concentration of solids is most prevalent in the Santa Cruz Valley north of Tucson, where the upper 300 feet of regolith is alluvial deposit.

Fluoride is a water quality problem in the region. In small quantities, fluoride is beneficial in preventing tooth decay, but in larger quantities, it can cause mottling of the teeth and skeletal fluorosis. Water containing more than 1.4 mg/l of fluoride is not ordinarily used for human consumption; the average concentration in the Tucson Basin is only half this--0.7 mg/l. High fluoride concentrations are found mainly in the Santa Cruz Valley north of Tucson and in smaller locations in the Avra and Altar valleys (U.S. Army Corps of Engineers, 1978).

Nitrate, a possible cause of methemoglobinemia in infants, is thought to be dangerous at concentrations above 45 mg/l. Such concentrations are found along the Santa Cruz throughout much of its course through Pima County. Since nitrate concentrations are generally related to human activities, notably the use of agricultural fertilizers and the discharge of sewage, nitrate levels in the ground are generally increasing.

According to Johnson (1978), groundwater found at lower depths may have higher concentrations of dissolved salts, and would therefore require extensive treatment facilities. The U.S. Army Corps of Engineers suggests that it is only fluoride which increases in concentration with depth, and that as much as 1.9 million acre-feet of the estimated recoverable groundwater down to 700 feet may be unsuitable for public supply. This represents between 4 and 5 percent of total supply.

Tucson's drinking water was rated highest for purity in a 1975 EPA analysis of 80 large cities. It "easily complies with the overall required purity standards as stated in the Clean Water Act. No problems are anticipated in maintaining that quality standard with the sources not available" (U.S. Army Corps of Engineers, 1978).

Water Distribution

The Southside, Avra Valley and Santa Cruz fields generally pump their water to transmission mains for transportation to the point of consumption. Wells in the Interior Field, close to the point of consumption, generally deliver water directly to adjacent distribution piping (City of Tucson, 1976).

Additional pumping is necessary to deliver the water from the Avra Field, across the Tucson Mountains. Ground level or elevated reservoirs are the predominant method of storage in the area. Transmission mains are generally from 24 to 48 inches in diameter.

Wastewater

Previously two separate sewerage systems served in the Eastern Pima County area, one operated by the city of Tucson and the other by the county, but in 1979 the city system was transferred to the county. Within the city, the system employs 952 miles of sanitary sewers of 6 to 78 inches in diameter, and includes two treatment plants. The Roger Road Wastewater Treatment Plant is the largest facility and processes the sewage from the entire city plus a part of the county to the south of the city boundary. This plant provides a variety of treatments: primary sedimentation, conventional activated sludge, biofiltration, and contact stabilization type activated sludge (U.S. Army Corps of Engineers, 1978). Total capacity is 37 mgd but present flow is about 27 mgd, all of which is ultimately reused by the Cortano-Marana Irrigation District. The second plant in the city is the Randolph Park Water Reclamation Facility with a projected capacity of 1.5 mgd, but an actual working capacity of 1 mgd due to problems in the biological treatment process. Built in 1975, this plant was designed to provide recycled water to three golf courses.

The Ina Road Wastewater Treatment Plant serves the county's major population centers which consist of the unincorporated sections of the Tucson metropolitan area located to the north of the city. With a pure oxygen activated sludge system and three standby oxidation ponds, the facility has a total capacity of over 25 mgd, but is presently processing 8.5 mgd. This wastewater is also used in the Cortano-Marana Irrigation District. The county also operates the smaller Highlands-Oro Valley Wastewater Treatment Plant.

Treated wastewater is discharged into the Santa Cruz River. In 1975 this amounted to 40,000 acre-feet and is expected to increase to 700,000 acre-feet by 2000. The Pima Association of Governments is currently developing plans to improve the Pima County collection and treatment facilities, and among their concerns is the possibility of reusing wastewater as a supply source. This topic will be covered in a later section on water conservation.

Wastewater is also produced in industrial activities drawing on privately pumped water. The most significant of these is mining since many of the other industries discharge their wastewater through the public sewerage system. PAG estimates that about 50 percent of the water used in the various mining processes eventually recharges the groundwater aquifer; the remainder is consumed.

Water Use Characteristics

Water use in Pima County can be divided into four main categories: water used for agricultural irrigation, industrial use, municipal use and recreational use. Table 67 depicts these use categories for Pima County and shows the county's current and projected water use figures (PAG, Water Resources Summary, 1978). The projected rates of overdraft in the county from 1980 to the year 2000 are outlined in Table 68. The discrepancy in the total use figures between Tables 67 and 68 is attributed to the inclusion of a reduction in agricultural lands in Table 67 while the data in Table 68 assumes a static level of agricultural land

TABLE 67

PIMA COUNTY WATER USAGE

Use Category	Annual Pumpage (ACRE-FEET)	(PERCENT)	Annual Consumptive Use (ACRE-FEET)	(PERCENT)
		1975		
Irrigation	283,000	64	246,500	73
Industrial	82,300	10	54,000	16
Municipal	67,200	15	29,000	9
Recreational	7,700	2	7,700	2
Total	440,200	100	337,900	100
		2000		
Irrigation	49,200	18	43,500	25
Industrial	102,100	37	71,300	41
Municipal	104,500	38	41,000	24
Recreational	18,100	7	18,100	10
Total	273,900	100	173,900	100

Source: Pima Association of Governments, Water Resources Summary (1978).

TABLE 68

TOTAL WATER WITHDRAWAL

Year	Total Withdrawal (ACRE-FEET)	Rate of Overdraft[1]
1980	337,000	-3.06
1985	346,500	-3.15
1990	356,000	-3.24
1995	365,500	-3.32
2000	375,000	-3.41

Source: Pima Association of Governments, Water Resources Summary (1978).

[1]Rate of overdraft = Total Withdrawal/110,000 acre-feet. 110,000 is the average annual long-term dependable supply. Assumes that projected increases in population and manufacturing and mining employment occur; and that cropped acres remain at 54,000 acres.

use. As discussed previously, cropped acreage is expected to decrease substantially by the year 2000, and therefore Table 68 may prove to be unrealistic.

Davis (1978) notes that 74 percent of the total consumptive water use in Pima County in 1975 was attributable to irrigation usage. Agricultural water consumption involves the crop's consumption factor, an irrigation efficiency factor and a leaching requirement factor. Of the 52,000 acres in Pima County used for agriculture, 13,700 acres are used in the production of upland cotton, 8,500 for sorghum, 8,200 for barley, 7,000 for wheat, 4,620 for pecans, 3,780 for lettuce, 2,700 for American Pima Cotton, 2,000 for alfalfa hay and the balance is made up by other crops such as other types of hay, corn, and peaches. Table 69 exhibits the consumptive water use by major crops in Arizona.

Industrial water is used in mineral processing, manufacturing, plant cooling, and electric power generation. As stated earlier, it is estimated that recharge water from mining uses represents approximately 50 percent of the water pumped (PAG, Water Use Information, 1978).

TABLE 69

CONSUMPTIVE WATER USE BY CROPS IN ARIZONA
(ACRE-FEET)

Crop	Growing Season From	to	Seasonal Water Use
Cotton	April	November	3.43
Alfalfa	February	November	6.19
Sorghum (grain)	July	October	2.12
Corn	March	June	1.63
Lettuce	September	December	.71

Source: Pima Association of Governments, Water Use Information for Pima County, Arizona (1978).

Municipal water is used for domestic purposes, both in-home and outside. It is also used for commercial or office facilities, schools and hospitals. In sewered areas, return flows are estimated to represent 53 percent of the pumpage (PAG, Water Use Information, 1978). Water used in parks, lakes, swimming pools, and so on, is included in recreational water use and the PAG defines water consumption in this category as equalling pumpage (Water Use Information, 1978).

For planning purposes, the Santa Cruz River Basin can be divided into two functional units: The Tucson District, which includes the city, and the remainder of the basin. The Tucson District water budget calculations can be seen in Table 70. Water use in the Tucson District has principally been for municipal purposes. The present sources of water supply and the corresponding capacities are listed in Table 71.

Tables 72 and 73 and Figure 21 furnish additional water use data for the city of Tucson. The city utility services a population of approximately 454,640 persons and projects this service area population to 714,114 by the year 2000. Figure 22 depicts the projected well capability of Tucson compared with projected peak delivery requirements. It is interesting to note that the graph shows a peak requirement of almost 160 mgd between 1976 and 1977. Other data from the city contradict these figures. They indicate an average use of 60 mgd and a

TABLE 70

UPPER AND LOWER SANTA CRUZ DISTRICTS WATER BUDGETS
(ACRE-FEET)

Year	Imports	Pumpage For Use	Pumpage For Export	Total Reqire-ments	Return Flows	Recharge	Comsump-tion	Dependable Supply	+Under-Draft -Over-Draft (9-8)	Rate
1975	25,100	73,900	-0-	99,000	42,300	38,400	60,600	44,000	-16,600	1.38/1
1980	34,600	65,600	-0-	100,200	46,200	41,800	58,400	44,000	-14,400	1.33/1
1985	43,800	64,100	-0-	107,900	50,500	45,700	62,200	44,000	-18,200	1.41/1
1990	54,700	61,400	-0-	116,100	54,600	49,400	66,700	44,000	-22,700	1.52/1
1995	66,500	56,400	-0-	122,900	58,800	53,100	69,800	44,000	-25,800	1.59/1
2000	80,700	50,100	-0-	130,800	63,000	56,900	73,900	44,000	-29,900	1.68/1

Source: Pima Association of Governments, Projected Water Use and Water Budget Calculations for Pima County, Arizona (1978)

TABLE 71

EXISTING WELL CAPACITIES: TUCSON
(MGD)

Location	Capacity
Avra Valley Well Field	10.6
Santa Cruz Well Field	17.4
South Side Well Field	11.5
Interior Wells	102.9
Del Oro	(2.3)
Catalina Foothills	(4.6)
Tanque Verde	(2.3)
Central	(90.8)
Mission-Avra	(0.5)
Tucson Mountain	(2.4)
TOTAL	142.4

Source: Pima Association of Governments, Water Use Information for Pima County, Arizona (1978).

TABLE 72

WATER UTILITY SERVICE AREA POPULATION

Year	Active Services	Service Area Population
1960	51,474	195,600
1965	60,500	229,900
1970	74,709	272,687
1975	101,636	376,053
1980	122,876[1]	454,640[2]
1985	141,110	522,110
1990	158,949	588,111
1995	176,471	652,944
2000	193,004	714,114

Source: Johnson (1978)

[1] Assumes 3.7 people per service.
[2] Includes private water company service areas.

TABLE 73

HISTORICAL AVERAGE AND MAXIMUM DAY PUMPAGE

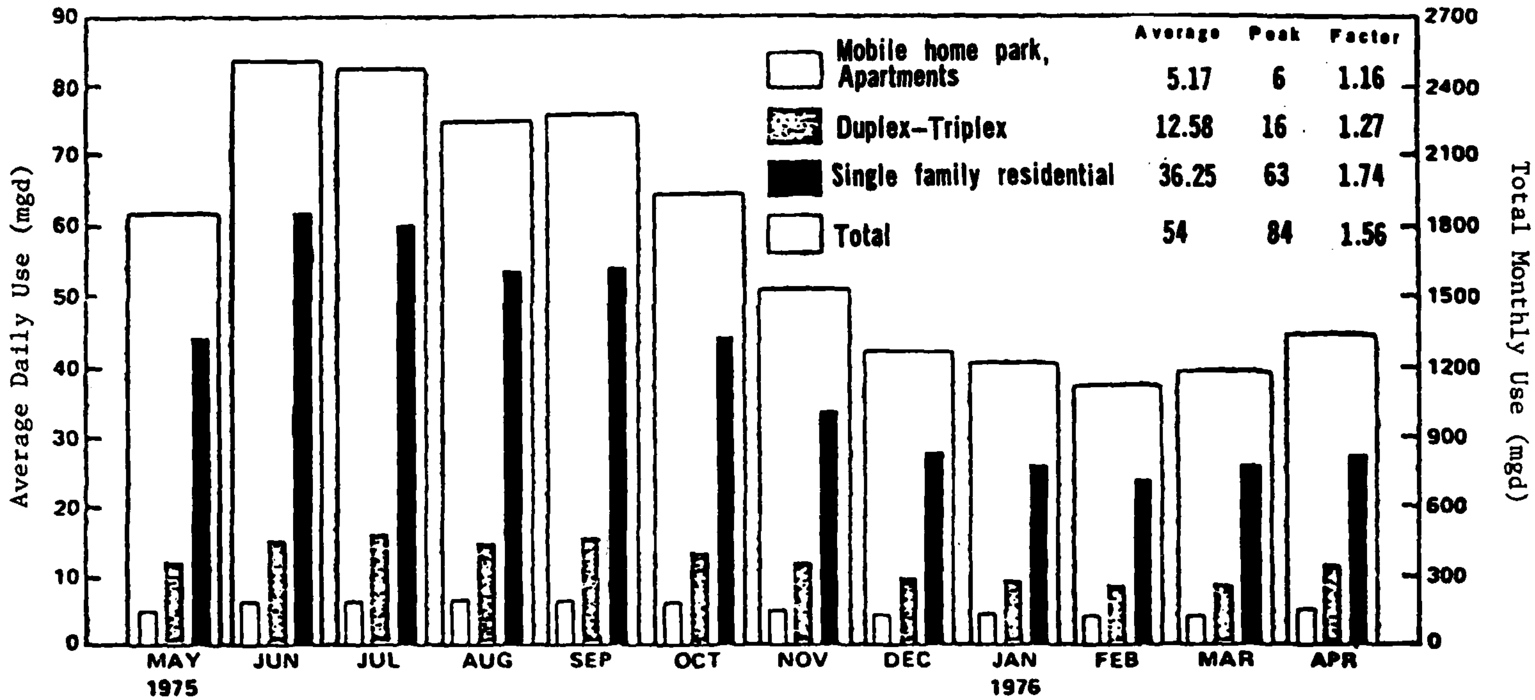
Fiscal Year	Average Day Pumpage (MGD)	Maximum Day Pumpage (MGD)	Maximum to Average Ratio
1969-70	51.2	99.1	1.94
1970-71	54.1	110.2	2.04
1971-72	57.8	112.3	1.94
1972-73	60.1	118.8	1.98
1973-74	75.4	103.4	1.73
1974-75	67.6	115.2	1.70
1975-76	70.0	117.6	1.68
1976-77	60.5	131.1	2.17
1977-78	59.4	112.1	1.89
1978-79	63.4[1]	118.8[2]	1.79

Source: Johnson (1978)

[1] Extrapolated based upon first 6 months.
[2] Summer 1978.

FIGURE 21

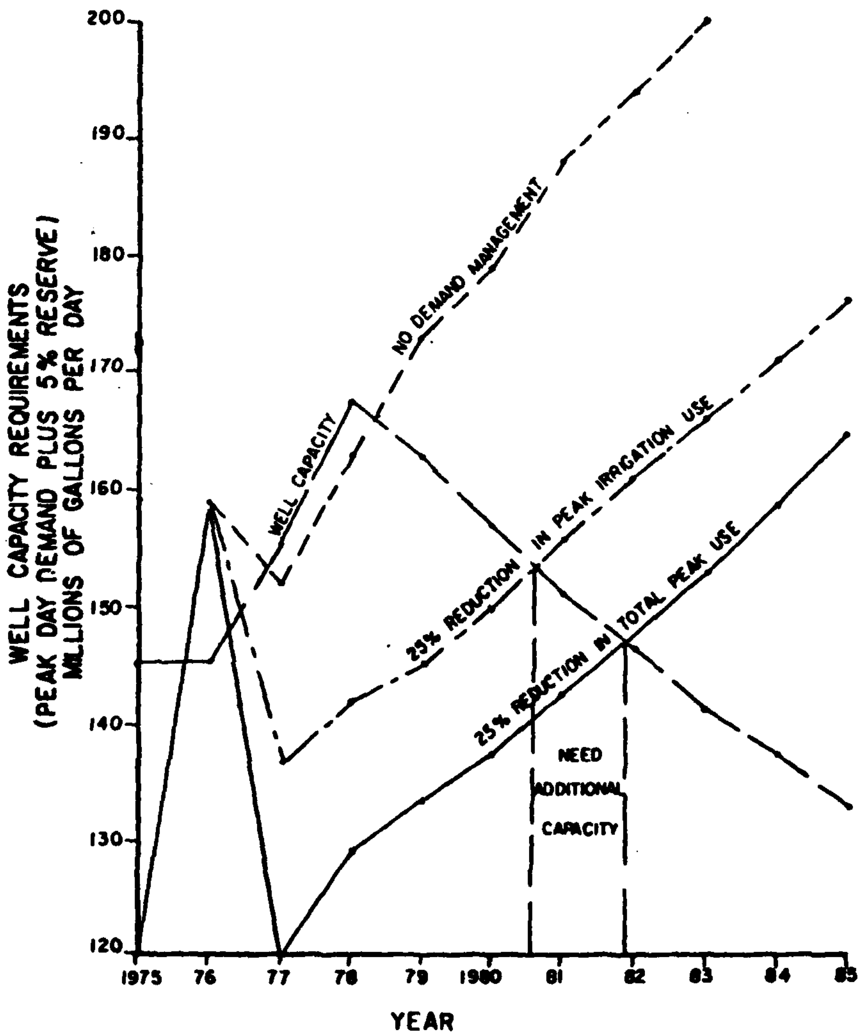
TUCSON WATER USE BY CUSTOMER CLASSIFICATION



Source: Wonders (1976)

FIGURE 22

PROJECTED WELL CAPABILITY COMPARED WITH PROJECTED PEAK DELIVERY REQUIREMENTS



Source: Davis (1978)

peaking factor of 2.0, giving a peak requirement of 120 mgd.

The existing Pima County wastewater flows are listed in Table 74 which also shows the future trends in wastewater flows to the year 2000. According to the PAG (Water Resources Summary, 1978), "The only major viable wastewater supply available for reuse is the 41,000 acre-feet of municipal and industrial effluent generated in the metropolitan Tucson area. This can be expected to increase to 70,000 acre-feet in 2000 and can be classified as a dependable source of water of a known quality." PAG also states that there is no wastewater reuse plan for the county which treats wastewater as a water supply in competition with other sources of water supply.

Water Conservation

The PAG (Water Conservation Strategies, 1978) has listed and described various water conservation strategies for the county (see Appendix H). Comparatively little has been done in the Tucson area to implement water conservation.

Much of the Tucson area is a critical groundwater zone which prohibits new well water from being applied as irrigation water for newly cropped acreage. Restrictions also exist on the amount of water which may be produced and moved from its source. Through the state legislature, the City of Tucson has attempted to obtain changes in the groundwater laws. The city is trying to secure the ability to purchase water rights without being required to first purchase the land.

The most widely publicized water conservation approach in the city has been the "Beat the Peak" program. Implemented in the summer of 1977 and aimed primarily at residential users and their lawn watering patterns, the program reportedly effected a 25 percent reduction in peak day usage (David, 1978) during the period July 1976-July 1977. Water use during the summer months was down 13.3 percent when compared to 1976 figures. A substantial rate increase was also introduced during this period. 1979 rates are of the increasing block type ranging from $0.60 to $0.75 per 100 c.f. for residential usage. A summer surcharge of up to $0.29/100 c.f. is added. Sewer rates are $0.43/100 c.f. based on winter use.

A close scrutiny of the data provided in the "Beat the Peak" reports suggests that the program's success, while real, may have been overstated. Both Johnson (1978) and Davis (1978) use summer 1974 as a base figure which in fact was an unusually dry hot period. Such a base would tend to overstate any water use reductions.

Wastewater reuse is another water conservation strategy that has been and is currently being studied. The Corps reports (1978) that "Independent studies have been completed regarding specific reuses such as for crop irrigation north of Tucson and for mine process water south of Tucson, but no comprehensive benefit/cost analysis has been done to determine the best reuse of the effluent, from among these competing reuse options." The Randolph Park Plant has been supplying recycled water to three golf courses, but biological problems in the treatment

TABLE 74

SUMMARY: WASTEWATER FLOWS 1975

AREA	Return Flow (ACRE-FEET)	Current Reuse (ACRE-FEET)	How Reused*	Volume Future Trend to 2000	Owner-ship	Central Location	Quality	Central Discharge
AJO								
Industrial	5900	2900	(1)	constant	Private	yes	unknown	no
Municipal	200	100	(2)	constant	Public	yes	domestic	yes
AVRA & Altar								
Irrigation	15,800	15,800	(1)	decline to 3400	Private	no	unknown	no
Industrial	2500	1300	(1)	constant	Private	yes	unknown	yes
UPPER & LOWER SANTA CRUZ								
Irrigation	20,200	20,200	(1)	decline to 3600	Private	no	unknown	no
Industry	45,700	22,900	(1)	constant	Private	no	unknown	yes
Municipal	41,200	37,100	(1)(3)	increase to 69,800	Public	yes	domestic	yes

Source: Pima Association of Governments, Water Resources Summary (1978)

*(1) Uncontrolled Recharge (2) Landscape Irrigation (3) Turf Irrigation

process have led to some clogging of sprinklers on the golf courses. Also, with no storage facilities, water is supplied constantly and this leads to continued sprinkling during periods of rain together with the use of drinking water during periods of peak use.

One study by Bailey (1979) investigated the feasibility of using effluent for mining process use. The study examined the projected wastewater sources, the mining companies' demand for the effluent and the Central Arizona Project (CAP). One of the major conclusions of the study was that "A wastewater effluent delivery facility could be implemented which would utilize reclaimed effluent in quantities approximately 35 percent of basin overdraft and which would provide revenue for full cost recovery over a 20-year operation period."

SUMMARY OF CURRENT AND FUTURE PROBLEMS

It is fair to say that Tucson's water problems are unique. It is the largest city in the country totally dependent on groundwater as a source of municipal water. A higher rate of groundwater extraction is unlikely in the future. Since Tucson is also experiencing rapid economic development and population growth, the inability to speed up groundwater extraction from current wells is crucial. Where Tucson is going to get the necessary water if its growth is to continue is a lively local issue; whether the growth should continue is another controversial subject.

The development of other water sources is also difficult. There are legal barriers to the extension of ground well drilling into the more remote areas of Pima County, and there are few alternatives to groundwater as a supply course, given the region's climate and topography. One such alternative, however, the Central Arizona Plan, is not expected to deliver water until at least 1987, and is in any case still in the planning stage and vulnerable to future decisions at the Federal level.

Water conservation is likely to be of central importance in allowing Tucson to accommodate its future expected growth. But so far, few conservation plans have been implemented. The Pima Association of Governments has begun examining water conservation measures, including wastewater reuse, the recycling of mining effluent, and the retirement of agricultural land which consumes large quantities of water. The latter has already been attempted but has run into certain legal, political, and institutional barriers. Other measures may also be controversial, and one likely source of controversy is water quality. At present, Tucson's water is of exceptional quality and any reduction in water quality due to the implementation of water conservation plans will undoubtedly be controversial.

One conservation plan that has been implemented is the "Beat the Peak" program, designed to reduce the water used during peak periods for such things a lawn watering. As a voluntary program, it seems to have had some success since its initiation in 1976. But the quantities conserved were minimal, given Tucson's overall water budget. The city

will need to consider a comprehensive water conservation plan, and the physical and institutional infrastructure that goes with it, in order to deal with the rapidly rising demand for water.

CHAPTER VIII

MEASURE-SPECIFIC ANALYSIS

This section describes the process of identifying those water conservation measures which are applicable to the Tucson metropolitan area, and of initiating the analysis of individual measures. Measure-specific analysis consists of such determinations as technical feasibility, social acceptability, and implementation conditions. The effectiveness of each measure in reducing future water use is estimated and the costs of implementation, as well as certain other advantageous or disadvantageous effects of implementation, are estimated. The results of these analyses form the basis for the evaluation to follow, which incorporates the characteristics of present and future water supply systems.

APPLICABILITY

Applicable water conservation measures for Tucson are those which address water uses which presently occur, or are expected to occur, within the water service area, and which are not now implemented or planned for implementation. These measures are identified as applicable irrespective of implementation requirements or costs, or of expected benefits. The types of water conservation measures considered are shown on Table 75, column 1; those found applicable are indicated by a "yes" under column 2.

Regulation

Since Federal and state laws and policies are not considered subject to change as a result of this study, they are not considered applicable components of a local water conservation plan. Other regulatory measures, however, including codes and ordinances and locally adopted restrictions on water use are all applicable measures. Those codes, ordinances, or restrictions which can be adopted on a contingent basis are considered applicable as well.

Management

Management measures include such categories as leak detection, land use policies, rate making policy, and tax incentives or subsidies. Available data on unaccounted-for water indicate that the Tucson Water Department's current leak detection program is effective, so leak detection is not considered applicable as a water conservation measure. Similarly, metering is not an applicable measure. Since Tucson now employs an increasing block rate structure with a summer surcharge, these rate making options are not applicable. Otherwise, all management measures are considered applicable.

TABLE 75

POTENTIAL WATER CONSERVATION MEASURES: TUCSON

Water Conservation Measures	Applicable	Technically Feasible	Socially Acceptable
REGULATION			
LONG-TERM			
Federal & State Laws & Policies			
A. Presidential policy	no		
B. PL 92-500	no		
C. 1977 Amendments (Clean Water Act)	no		
D. Safe Drinking Water Act	no		
Local Codes & Ordinances			
A. Plumbing codes for new structures	yes	F	P
B. Plumbing codes--retrofitting	yes	F	P
C. Sprinkling ordinances	yes	F	F
D. Changes in landscape design	yes	F	F
E. Water recycling	yes	F	F
Restrictions			
A. Rationing			
1. Fixed allocation	yes	F	
2. Variable percentage plan	yes	F	
3. Per capita use	yes	F	
4. Prior use basis	yes	F	
B. Restrictions on specific uses			
1. Recreational uses	yes	F	
2. Commercial & institutional uses	yes	F	
3. Car washing	yes	F	
CONTINGENT			
Local Codes & Ordinances			
A. Sprinkling ordinances	yes	F	F
B. Water recycling	yes	F	F
Restrictions			
A. Rationing			
1. Fixed allocation	yes	F	F
2. Variable percentage plan	yes	F	F
3. Per capita use	yes	F	F
4. Prior use basis	yes	F	F
B. Restrictions on specific uses			
1. Recreational uses	yes	F	F
2. Commercial/institutional uses	yes	F	F
3. Car washing	yes	F	F

TABLE 75 (continued)

POTENTIAL WATER CONSERVATION MEASURES: TUCSON

Water Conservation Measures	Appli-cable	Technically Feasible	Socially Acceptable
MANAGEMENT			
LONG-TERM			
Leak Detection	no[1]		
Rate Making Policies			
A. Metering	no[1]		
B. Rate design			
1. Marginal cost pricing	yes	F	F
2. Increasing block rates	no[1]		
3. Peak load pricing	yes	F	F
4. Seasonal pricing	yes	F	F
5. Summer surcharge	no[1]		
6. Excess use charge	yes	F	F
Tax Incentives & Subsidies	yes	F	F
CONTINGENT			
Rate Making Policies			
A. Rate design			
1. Marginal cost pricing	yes	F	F
2. Increasing block rates	yes		
3. Peak load pricing	yes	F	F
4. Seasonal pricing	yes	F	F
5. Summer surcharge	yes		
6. Excess use charge	yes	F	F
EDUCATION			
LONG-TERM			
Direct Mail	yes	F	F
News Media	yes	F	F
Personal Contact	yes	F	F
Special Events	yes	F	F
CONTINGENT			
Direct Mail	yes	F	F
News Media	yes	F	F
Personal Contact	yes	F	F
Special Events	yes	F	F

yes--applicable to conditions presently existing, or expected to exist in Tucson
no--not applicable to Tucson conditions
F--feasible or acceptable under present conditions, or conditions expected to exist in Tucson
P--potentially feasible or potentially acceptable; feasible or acceptable only if conditions change in specified ways
[1]Measures already implemented in Tucson

Education

All educational efforts directed to the conservation of water are considered applicable measures. The City already operates an educational program in its "Beat the Peak" campaign, but many other types of educational efforts could be considered.

TECHNICAL FEASIBILITY

Technically feasible measures are those which, properly implemented, can reasonably be expected to reduce future water use by some measurable amount. Briefly, all of the measures found applicable for Tucson are considered to be technically feasible, as shown on Table 75, column 3. Some possible configuration of each measure is assumed to exist which would reduce future water use.

SOCIAL ACCEPTABILITY

The purpose of a study on the social acceptability of water conservation measures is, by definition, the determination of whether certain measures are or are not socially acceptable, that is, acceptable to the community in which they are proposed. But unlike the determination of technical or even economic feasibility, such clearcut decisions are rarely (if ever) attainable in the area of community acceptance. Both the number and complexity of factors involved preclude the prediction of community response with certainty. The goal, then of such efforts is a more modest one: To increase the quality of the judgments made as to the probable response a community will make to a proposed measure.

Community response to a conservation measure is, in important part, a function of its congruence with the community's dominant social ideologies. The question is: Is a specific measure perceived as being harmonious with those basic values, beliefs, attitudes and feelings that define a community's commitments, or is it seen as in some way violating them? In so far as progress is made in answering that question, one's judgment as to the social acceptability of the measure improves.

It is clear, then, that to serve the ultimate purpose of making such judgments, it is necessary first to achieve some understanding of those ideological themes in a community that are of relevance to conservation. Thus, the immediate goal of this study is the identification and delineation of those community values, beliefs, attitudes and feelings that will influence response to any and all measures.

The study procedures (sampling and methods) used to gain an understanding of the social ideologies that characterize Tucson are summarized in the introduction to this volume. However, because a study of social acceptability involves goals and methods that depart from traditional Corps interests and expertise, it may be useful to look again

at several issues before the discussion of Tucson begins.

The studies reported here employ interviews with persons perceived by citizen advisors as exercising considerable influence in the community, and mail questionnaires directed to a representative sample of the general public. In both cases several kinds of issues were discussed. The relevance of obtaining the evaluations of respondents to specific conservation measures that might be proposed in the future is self-evident. An example would be plumbing codes that specify water-saving appliances. But what might be less immediately understood is the rationale for raising matters in these discussions that, at best, may seem only tangentially related to water conservation, and at worst, would appear to be totally unrelated. Examples of such issues are water rights, alternatives for increasing water supply, or the question of inhibiting or fostering urban growth.

Indeed, such issues do not constitute conservation measures. The discussion of them is, rather, a means to an end. For it is by way of their consideration of such issues, often somewhat controversial, that respondents reveal those values, beliefs, attitudes and feelings that characterize their social ideologies. Thus, although the restriction of urban growth may not be a possible conservation measure (and certainly not one in which the Corps would take a position), discussion of it may well produce the clearest picture of those values and principles of judgment that the community uses in its evaluation of any and all conservation measures. In other words, discussion of such issues is often, indeed usually, more successful in leading to the identification and delineation of basic values than is the discussion of specific and circumscribed conservation measures.

It must be reemphasized that the immediate goal of a study on the social acceptability of conservation measures is to understand the community, to put a finger on its pulse, to get a feel for the various forces at work with it, to know who holds what values and why. For it is only such an understanding that can serve as an enduring base for judging community response to any specific measure.

This report presents two versions of the analysis of social acceptability data. The following sections present the substance of the findings in a condensed and concise form. A considerably more detailed analysis of both the interview data and the survey questionnaire data is presented in Appendix E; there, especially, an attempt is made to preserve the original character of the interviews in which the respondent often presented his position in an unrestrained and irrational manner, for in understanding social ideologies, the strength and quality of the effect that is associated with a postion is as important as the substantive aspect of the position itself. It need hardly be added that the views expressed in the data, as well as the passions with which they are held, are totally disassociated from the Corps itself.

Personal Interview Analysis

General Issue: Urban Growth

In Atlanta, it was the discussion of the issue of urban growth that proved to be of most relevance in identifying the underlying values of that community. While there were differences between various interest groups on the nature and causes of growth, in the end all forces were allied to promote it. What continued to differentiate among various groups were the principles according to which growth should operate, according to which the benefits and costs of growth should be distributed. There were those in Atlanta who were more or less on the side of the political process being used to control growth; implicit was their judgment that the free market system left to itself fails to result in social and economic justice. And there were those who were more or less on the side of the political process being used to keep growth separate from social issues; implicit was their judgment that the free enterprise system is the basis of social and economic justice.

But as the phrase "more or less" implies, these were philosophical polarities reached only by the logical extension of what was said. In actuality, Atlantans were "moderates," those who faulted the system of free enterprise were not opposed to it; they believed in its virtues and wanted only to temper its effects. And those who asserted free enterprise's virtues were nonetheless ready to accept, indeed, to demand, some interferences with its processes. The voices of both sides were muted by a mutual uneasiness that neither position could be held absolutely.

This is not so in Tucson; positions there tend to be extreme, and there would seem to be little appreciation of the "other's" side that would modify one's own position and lead to tolerance of another's views, or to compromise. Ideologies are stated boldly and fervently, there is little sense of the subtle complications that give pause. The opposing ideological poles, then, that are illuminated by the respondents' discussion of urban growth or its limitation can be clearly delineated.

The dominant value system in Tucson (congruent with what one respondent called "our state's senator and our state's right-to-work law") is the utter belief in the justice of the benefits that result from free enterprise, from the operations of the free market. It is this economic model of the free market that is generalized to serve as the principle according to which all social processes should operate. Thus, the limitation on urban growth must be allowed to either happen or not happen "as it will." Any use of political power--to shape, mold, or control growth--is to be avoided, since rules and regulations on growth would only interfere with what is seen as a self-regulating process, as "natural" and effective and as responsive as "price" is to the law of supply and demand.

Of course, there is a minority in Tucson that represents a diametrically opposed set of values. And its basic ideology is also illuminated by their discussion of growth, and by their comments on those who advocate growth:

> They (those who favor growth) believe that government's only role is to provide service—no rules, no regulations, not even guidelines. They feel no responsibility to the community. There is a belief—'It is my land, and I have the right to do anything I want with it regardless of what the consequences it might have for others'; it is property rights gone amuk. There are still high rise buildings that don't meet fire codes, but although they've been cited, the city won't publish the names of the offenders.

Even this one quotation makes clear the underlying ideology: This respondent does not believe that the pursuit of individual interests is the way to bring about the common good; rather, the application of the principle of the free market to social affairs is judged to be inappropriate.

The logic of this group's position is that the distribution of economic benefits following from a free market principle is unjust, because it results not from the free play of individual effort but from the accidents of birth, from fated memberships in race, class, and nation. It is such vast social forces, not individual character, that are seen as determining most of who and what man is. To insist then, that a free market system should be applied to human affairs is illogical and morally questionable in that its assumption of equality is invalid. For respondents of this ideological persuasion justice cannot be left to the economic marketplace; the common good is a political responsibility. It is not government's prerogative, it is its duty to control the economic sector of society.

For a brief period, roughly 1972-1976, Tucsonians of this persuasion gained political control. They were perceived as using political power, via zoning rules, utility regulations and prices, and so on, to regulate and limit urban growth. These actions evoked a powerful mobilization of conservation response which required political control of the city. Since then, the dominant ideology in the community has remained the traditional Arizona one of unfettered growth; it is equated with freedom and the American way; it is "what made this country great." The forces aligned against it are perceived as being either in disarray or as becoming a threat only in the somewhat distant future. For the present, pro-growth forces remain in firm control.

In the end, then, Atlanta and Tucson are alike in that a growth ethos rests upon a core ideology that essentially generalizes the principles of capitalism to social relations. The cities differ only in the degree of comfort with which this ideology is held: Atlantans are somewhat uneasy over the assumptions that holding such values makes necessary; they are troubled by possible illogicalities and possible

immoralities. Not so the respondents of Tucson; they have no doubts.

Specific Conservation Measures

Lawn Watering and Education: Tucsonians are convinced that they have demonstrated the efficacy of education as a conservation measure; they point to their "Beat the Peak" program, designed to lessen residential outside use of water between 4:00 and 8:00 PM. This public relations effort has indeed effectively reduced peak water demands during the past three years.

In their judgment the accomplishment of such a significant reduction for so long a time must be interpreted as success in the changing of behaviors and values and aesthetics. Thus, habits have been broken (people do not water their lawns or wash their cars in the late afternoons or early evenings), values have been modified (the outdoor use of water during the prescribed hours is seen as "sinful" and violators are "reported" to authorities), and aesthetics have been altered (the ideal of midwestern green is beginning to give way to "desert-is-beautiful"). Some consequences, such as the changeover to desert landscaping, promise permanence. There is the conviction, then, that adult education or resocialization for conservation works.

Agriculture: Tucson lives on underground water. So do the farmlands surrounding it. That water comes from a shared basin. Given a finite pool, what one user takes decreases the amount available to other users. Whatever figures are quoted, it is clear that, by far, agriculture uses most of the water. That fact is the basis for a solution to future water needs in Tucson proposed repeatedly in the interviews: There would be no water shortage, regardless of the rate of future urban growth, if the water that agriculture uses were diverted to residential use. Whenever this idea was proposed, it was accompanied by the conviction that this is exactly what will eventually come to pass.

This expectation of the future phasing out of agriculture exerts a profound effect on the general receptivity to water conservation measures. Thus, the "Beat the Peak" program of decreasing outside watering, water-saving plumbing appliances, renovated wastewater—all of which are also seen as laudatory—are often seen as trivial. As one respondent said:

> Why waste time and energy and money on things that will yield so little water. We're just going to take it from the farmers.

The Central Arizona Project and the Papago Indian Lawsuit: There are two issues of water supply in the Tucson area that have implications for conservation in that their outcome will determine its urgency; these are the Central Arizona Project (CAP) and the Papago Indian Lawsuit. Both are extremely complicated issues and would require considerable study to unravel their complexities to the points of confident understanding. However, here, the interest is in how these two issues are perceived by those interviewed.

Although there is considerable misunderstanding and disagreement regarding the CAP (who will benefit and who will pay), it seems to be the consensus that it will be built and that it will help to avoid future water shortages.

While all the respondents were familiar with CAP issues, the Papago Indian Lawsuit is another story. Only a few are familiar with it, with what it asks and what it might mean. Essentially, the suit refers to the agreement creating the Indian Reservation which promised to forever maintain the previously unappropriated water--its quantity and quality--which the Indians enjoyed at the time or which might be needed for the purposes of the reservation.

Tucson, and other water users such as agriculture and the mining industry, take their water from the same basin as the reservation. The rate of this use has far exceeded recharge and the water table has fallen dramatically. As a result, the wells of the Indians have to be deepened and their stream no longer flows.

If the suit is taken literally, restoration of the Indians' original water status would require restoring the basin's water table. The most knowledgeable respondents were agreed that this is not possible. However, in their judgment, the treaty clause could be used as leverage to gain, first, that share of available water needed for reservation farming, and, second, a further share of water which they hope to sell to economically benefit the tribe.

Those respondents who know most about the pending suit agreed that the Indians, *in or out of court, would win a settlement.* In the end it means that the cost of water in Tucson will increase, perhaps substantially, and thus, so might the motivation to conserve.

Questionnaire Analysis

In order to determine the response of the general public in Tucson to water conservation, a questionnaire was mailed to a sample of 750 persons selected at random from the metropolitan Tucson telephone book. As in the Atlanta survey, this questionnaire presented eight conservation measures chosen to represent likely options. But also presented were two additional water conservation measures thought to be particularly relevant to the Tucson area. These two "site-specific" measures are:

I. Farmers in the region grow only those crops which require relatively little water.

J. Landscaping of new homes uses only plants adapted to the aridity of the region.

(see Appendix B for measures A through J).

Of the 750 questionnaires mailed, 82 failed to reach the intended respondent, resulting in a net mailing of 668. And of these, 177, or 26 percent, were completed and returned.

As in Atlanta, a special interest sample was identified by the U.S. Army Corps of Engineers in Tucson on the basis of past interest expressed in water-related issues. Sixty-nine out of the 200 questionnaires sent to this special interest group were completed and returned, a response rate of 35 percent. A comparison of the response given by these two groups reveals that their level of expressed knowledge is almost identical: both groups express a great deal of familiarity with the measures presented.

Again, as in Atlanta, both the general public and special interest group expressed similar attitudes toward conservation measures. Therefore, although the conclusions reported here stem from the data provided by the general public, these conclusions are applicable to the special interest group as well.

In general, the response of the general public in Tucson to water conservation is exceedingly high--over 95 percent expressed favorable attitudes toward the water conservation measures presented. There is no statistical relationship between an individual's degree of approval of water conservation and his age, sex, or formal education. And, virtually everyone who strongly favors water conservation also approves of government enforcement of conservation measures. However, this does not mean that residents in Tucson would be equally receptive to government enforcement of each of the ten water conservation measures.

More specifically, the most highly favored water conservation measures are sewage reuse and education, and the least favored are pricing and control of urban growth (Table 76). Analysis of the four questions for each of the eight water conservation measures yield additional information (Appendix E).

There is little or no relationship between how much an individual knows about a specific water conservation measure and how highly that measure is rated overall. Moreover, a low overall ranking of a specific water conservation measure does not imply ignorance of the measure. There is, however, a weak relationship between an individual's perception of the effectiveness and economy of a specific conservation measure and its overall evaluation. Finally, there is some evidence to suggest that if people are given the opportunity to learn more about a particular measure, they tend to evaluate it more favorably--if true, an educational campaign would hold promise.

Shifting attention to a single measure, we find that nearly half of the respondents know little or nothing about pricing as a water conservation measure. And, although over half of the sample perceived pricing as effective in saving water and economical, 70 percent are against implementation unless the need for water is at least moderately serious. Finally, there are no age, sex, or educational differences in attitudes toward <u>any</u> question on price, useful information if an education program were to be designed.

Implication of Results

As with Atlanta, the study on social acceptability in Tucson,

TABLE 76

WATER CONSERVATION MEASURE RANK
ORDERED ACCORDING TO OVERALL EVALUATION: TUCSON

1. Sewage reuse.

2. Educational campaigns.

3T. Building codes require water conserving fixtures.

3T. Desert landscaping.

5. Individual installation of plumbing devices.

6. Lawn-watering reduced.

7. Farmers grow water-frugal crops.

8. Government intervention during drought.

9. City controls urban growth.

10. Pricing.

although equally brief and limited, produced clear outlines of major ideological themes as well as detailed assessments of a number of specific conservation measures.

Once again the task becomes one of speculating on the possible relationships between a data-based sense of community values and a selection of conservation measures. The question this inquiry asks is: If a certain measure is proposed, what chance does it have of being accepted? As a preface to this examination, perhaps earlier cautions should be repeated: the goal of a study of social acceptability is to improve judgements made of the probability of community acceptance of rejection. To do this involves the processes of speculation and conjecture, that is the making of inferences from inconclusive evidence. To be honest, the aim of a study of social acceptability is to provide such inconclusive evidence, on the logic that it is better than no evidence at all.

Pricing

To appreciate the current use of increasing block rates as a

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THE EVALUATION OF WATER CONSERVATION FOR MUNICIPAL AND INDUSTRI--ETC(U)
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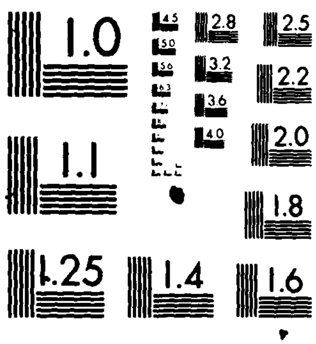

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

conservation measure in Tucson, some history is necessary. Prior to 1975, Tucson had a long-established price structure in which variance was based primarily upon the costs of delivery. There were three rates: a "low" charge within the city limits, a "moderate" charge in the area on the periphery of the city, and a "high" charge in areas extending beyond. Secondarily, there was a minor, indeed, insignificant, rate increase based on amount of water use.

Then, in 1976, major and highly visible changes in water pricing policies were inaugurated--a highly complex increasing block rate structure was interwoven with a complicated system of delivery charges. Quite naturally, these water policies did not please those whose water bills were substantially increased.

But more important, these water policies, most particularly the dramatic increases in delivery charges, were perceived by certain community powers, notably homebuilders and land developers, as part of the encumbent city government's attempts to limit Tucson's growth. They organized, and through their leadership and money, promoted and channeled public outcry, eventuating in a successful recall election. The newly elected officials proceeded to do more than retreat to the previous rate structure, they did away with all rate differentials whether based on amount of water used or on costs of delivery. Shortly thereafter, however, increasing block rates were not only restored, they were greatly strengthened, but to this day, there is no recognition in the rate structure of the substantial difference in costs of delivery between city and distant, expanding suburbs. Thus, the concept is using pricing to conserve water by reducing demand <u>per household</u> was supported and advanced, but the principle of using pricing to conserve water by limiting the <u>number of households</u> *was rejected*.

But this plotline is not the full story. There are several issues that deserve a closer look, first, the response of the construction interests: The respondents were agreed that their political mobilization was a response to what they saw as an economic threat. A no growth or limited growth or controlled growth policy would have seriously hurt their business. However, there were moral as well as economic concerns involved in their efforts to remove the encumbents from office. For in their eyes the powers of government were being wrongfully used to restrict the exercise of two freedoms basic to American life--locally, they had intervened in the workings of the market, and, nationally, they had attempted to restrict movement:

> 'Nobody has the right to tell somebody that you can't move to Tucson, and in effect, that's what you're doing when you make the price of water prohibitive. And who's to say that you can't build homes for them. They'll come anyway. What do you want, a ring of trailer camps around the city?'

Such sentiments, frequently voiced, reveal the deeply felt ideological offense that was a part of their entrance into the field of politics.

In addition to being perceived as violating the right of mobility and the freedom of the marketplace, rates based on delivery costs were also seen as at odds with another important value--Tucson's dominant definition of equality.

The concept of equality most favored by the Tucson respondents is a literal one: Everyone is to be treated the same way, rich or poor, inner city or foothill suburb, those of luxurious or spartan life style. In terms of the pricing of water, this translates into a simple maxim: Everyone should be charged the same cost for the same amount of water, and that means the same price per gallon regardless of where one uses it. Because variation in price based on delivery costs is perceived as clearly correlated with status differences in neighborhoods, they raise the suspicion that those who strive to raise their standards of living are being punished for their achievement; such rates constitute a discriminatory tax on the "rich." It was such arguments incorporating such values that pressed the public to change their elected officials.

Rate differences based on amount of water used to manage to avoid the charge of being discriminatory--for no matter who uses the water, and regardless of where it is used, greater use means a higher rate. No one is favored and no one injured; it is "fair." The use of pricing as a conservation measure has succeeded in Tucson because it is tied to the value of equality.

To say that pricing is successful as a conservation measure in Tucson is not to say that it is popular. Indeed, the questionnaire data show the opposite--it is ranked <u>last</u> in overall evaluation of the ten conservation measures the public reviewed. And indeed, over two-thirds (69 percent) of the sample feel that it should be implemented only when the water supply is seen as constituting a fairly serious problem. But it is these same figures that clue the reason for its acceptance because Tucsonians <u>are</u> concerned over their water supply. However begrudging, it appears that the Tucson public will accept a conservation measure, even one that hurts them economically; it is perceived as fair and necessary.

It should be remembered that prior to the political furor resulting in the recall election, Tucson had had a variable rate structure based on delivery costs that had encountered no substantial opposition. But the political processes provoked by its extension suddenly spotlighted the policy and made its ideological base visible. The public's values were then "energized" and their power of decision exercised.

Plumbing Appliances

Paradoxically, in lush, green Atlanta with rain, river, and lake, a plumbing code has recently been enacted mandating the use of low-flow appliances in new construction, while in desert Tucson, with a dramatically falling groundwater level, with a high visible need for water, with well-publicized water conservation programs, such a code has not yet been considered. An attempt to understand why is, at the same time, a way of estimating the measure's social acceptability.

When the idea of such a measure was presented to them, the response

of most respondents was puzzlement at the lack of such a code. Challenged, the respondents offered possible reasons:

> "It may be that the City Council wants to stay away from favoring particular manufacturers."

> "It would be yet another regulation, and that would mean yet another building inspector."

Both answers identify an ideological theme that characterized Tucson and which acts unconsciously to screen out from consideration a measure that might offend it. Thus, both responses assume the ideological stance that government should avoid interfering with business, that it shouldn't intervene or participate in market affairs where economic forces alone should operate.

Such, then, may be the values and attitudes that, probably unknowingly, have kept plumbing codes from consideration as a conservation measure, and, of course, it is these very same values and attitudes that would have to be overcome, or rather, satisfied, if plumbing codes were to be made socially feasible.

As the analysis of plumbing codes in Atlanta revealed, it is likely that the measure could be defined and presented in such manner as to make it sufficiently congruent with Tucson values. The logic that the proposal must follow is this: Such a code does not interfere with the free play of economic forces in the market; it does not affect the cost of home building or the price of home buying as the low-flow appliance costs the same as the standard appliances, nor does it disadvantage the retailer of plumbing appliances as implementation of such a code could be dated to permit liquidation of standard inventories.

Interestingly, each of these considerations was offered by the respondents themselves in their discussions of the measure's possibilities. And in the end, there was general agreement that essentially nothing "stood in the way" of such a code being adopted.

Yet there was no enthusiasm. While there was agreement that it was reasonable, harmless, that it wouldn't cost anybody anything, that, indeed, it might even be a selling point to those home buyers who were conservation-minded, so was their agreement that it was essentially idle, that the amount of water such a measure would save was insignificant, hardly worth the effort. And this conviction is not so easily overcome.

An attitude which dismisses conservation efforts as trivial is a function of attitudes toward water supply. There is the determined, albeit uneasy, belief in Tucson that problems of urban water will be solved through augmentation of supply. To look in the other direction, that is, toward solution through decreasing demand, is rarely even considered--for one reason, because it would have serious implications for what is seen as the city's unlimited potential for growth, a belief that functions as a point of honor for Tucson. All eyes, then are fastened on supply possibilities--the pipelines of the central Arizona Project, retired farming land, deeper wells.

In the content of these convictions, the prospects of a plumbing code enjoying energetic support form community powers are dim. On the other hand, at the worst, it would be viewed as innocuous, and, at best, as "good for PR" for both city officials and the home construction industries. The social feasibility, then, of implementing a plumbing code for conservation is neither poor nor good, but fair, in that it is a function of the absence of opposition rather than the presence of support.

As measured by the questionnaire, the public's stance on plumbing codes mirrors, in great part, the position of the Tucson interviewees just described. Thus, they too are generally uninformed of the use of such codes as a conservation measure (it ranks ninth out of ten regarding knowledge about); yet, at the same time, they are positive about the idea when it is presented to them (it ranks third out of ten in overall evaluation). It would appear, then, that public response to its proposal would echo the unenthusiastic endorsement of the city's powers--a stolid acceptance.

Acceptability of Specific Measures

The application of this analysis of social acceptability is illustrated by the fourth column in Table 75. Of the 38 classes of measures found to be technically feasible, 29 are shown as socially acceptable, and an additional two are given as potentially socially acceptable. Seven measures are assumed to be socially unacceptable. These seven measures include all forms of long-term rationing and restrictions on water use. This determination reflects strong beliefs regarding unrestricted access to water, beliefs which are not likely to be susceptible to manipulation. While prolonged water supply deficiencies might eventually modify the view of water as natural endowment, actions by state, regional, and local agencies seem unlikely to do so.

The same sensitivity to government intervention in the process of water use raises concern regarding the acceptability of other measures, such as those involving plumbing codes. For such measures to be acceptable, they would have to be designed with a view to public acceptance, and may also require some preparation and persuasion of the affected groups. These measures are, therefore, labelled as potentially acceptable. The remaining classes of water conservation measures are considered implementable on the basis of this examination of social acceptability.

IMPLEMENTATION CONDITIONS

Following consideration of social acceptability, the required implementation conditions for the remaining water conservation measures must be determined. In some cases, this will require defining a measure more specifically, or subdividing a measure into several related or alternative measures. For example, information obtained in the course of the investigation of social acceptability reveals some sensitivity to the

use of ordinances and codes to legislate water use changes. Plumbing codes applicable to new construction are considered only potentially acceptable for this reason. A plumbing code change could be designed, however, which would avoid most types of opposition, if it could be viewed as relatively innocuous and not harmful to any influential group within the community.

To provide another example, changes in landscape design (changes from humid climate to desert vegetation) are classified as acceptable in Tucson. Several specific but different water conservation measures can be devised, all of which have the effect of bringing about landscape changes. Changes may be effected by educational efforts (as they are now), by regulations affecting new construction, by public initiative with respect to public lands, by outright subsidy, by providing subsidized loans, etc. Some of these measures could be employed in conjunction with others, while other measures may be mutually exclusive.

In the present study, 31 types of water conservation measures have been shown to be socially acceptable or potentially socially acceptable. Some of these measures are broadly defined, suggesting the possibility of a substantially larger number of specific measures requiring analysis. Due to time and resource constraints, only three specific measures have been selected for further analysis here. These include a plumbing code change affecting new construction, a change in the structure of water and wastewater rates, and a system of subsidized loans for landscape changes. Implementation conditions for these measures are discussed in the following paragraphs.

Measure T1--Plumbing Code Change

A plumbing code change requiring all new toilets to have a maximum flush volume of 3.5 gallons and all new showers to use a maximum flow rate of 3.5 gpm could be adopted for the City of Tucson and implemented as early as 1980. Local agencies which normally enforce building codes and standards could monitor compliance with these specifications. Since the function of the water fixtures is very similar to that of older types, no inconvenience or consumer resistance to the change is expected.

Measure T2--Change in Price Structure

Although Tucson already uses an increasing block rate structure specifically designed to reduce water use, further reforms could be considered. For example, a change to rates based on the relevant marginal costs would appear to be a feasible measure. Such a change could be implemented by the City of Tucson Department of Water (for water rates) and the Pima County Wastewater Management Department (for wastewater rates). One important feature of the marginal cost based pricing system would be integrated treatment of water and wastewater rates, which are presently calculated and applied separately.

Measure T3--Subsidized Loans for Landscape Changes

Another socially acceptable measure which would be implemented in Tucson is a program providing low interest loans to residents for

purposes of changing to desert vegetation—i.e., vegetation requiring little or no irrigation. The source of the loan funds would be bonds issued by the municipality; interest rates to borrowers would be set just high enough to recover interest paid by the City plus administrative costs of the program. It is anticipated that this would provide funds to residents at an interest rate at least five full percentage points below that commercially available for the same purpose. The cost of employing desert vegetation in new developments is comparable to that of conventional vegetation, so the loan program would be applicable to existing housing units only.

For purposes of illustration, it is assumed that 60,000 existing residential properties in Tucson could potentially change to desert vegetation, and that the average irrigable area per property is 5,000 square feet. It will be assumed that the loan program will be active for ten years, and that homeowners will gradually adopt desert vegetation over the full period, 10 percent of the total number of adopters doing so each year. The total number of adopters will depend upon the perceived economic impact of adoption, as well as various other factors, including aesthetic preferences and peer pressure. The economic impact can be reviewed quickly by noting that conversion of one square foot of lawn could cost as little as $1.40, which would be equivalent to $0.089 per year if amortized over 50 years at 6 percent (a probably subsidized interest rate). This installation eliminates the necessity for irrigation totalling 30 to 40 inches per year. Forty inches of irrigation on one square foot is 24.9 gallons of water.

The cost of saving water is, therefore, at least $0.089/24.9 gallons, equal to $0.0036/gallon or $3.60/1,000 gallons. Since this figure is much higher than any actual or anticipated water price, there would appear to be no economic incentive for landscape changes of this type. Very few residents would be induced to adopt this measure by a subsidized loan program, therefore. Undoubtedly, some will implement changes for aesthetic or other reasons, but they would probably have done so in the absence of the subsidized loan program. To expect additional adopters because of the loan program implies sensitivity to economic incentives; the same sensitivity would frequently rule out participation in the first place.

It is concluded, therefore, that the coverage of this measure is relatively small. It is assumed that only five percent of eligible properties (0.05 * 60,000 = 3,000) eventually change landscape design, doing so at the rate of 300 properties per year.

EFFECTIVENESS

Effectiveness is estimated by the following expression:

$$E_{ijt} = Q_{jt} * R_{ijt} * C_{ijt}$$

Where: E_{ijt} = effectiveness of conservation measure i for use sector j at time t, in quantity per unit time (e.g., gallons per day)

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TABLE 77

FORECAST WATER USE FOR TUCSON

	Water Use (MGD)					
	1980	1990	2000	2010	2020	2030
Single-Family Residential (Domestic	24.4	31.4	38.1	43.9	49.8	55.6
Single-Family Residential (Seasonal)	13.1	16.9	20.5	23.6	26.7	29.9
All Multi-Family (Domestic)	7.1	9.1	11.0	12.7	14.4	16.1
All Multi-Family (Seasonal)	1.8	2.4	2.9	3.3	3.7	4.2
Commercial	12.8	16.5	19.9	23.0	26.1	29.1
Industrial	2.5	3.2	3.9	4.5	5.1	5.7
Unaccounted for	6.3	8.1	9.7	11.3	12.8	14.2
TOTAL	68.0	87.6	106.0	122.3	138.6	154.8

TABLE 78

WATER USE PATTERNS: TUCSON (1975-1978)

Customer Class	Percent of Total Use	Percent Seasonal[1]	Average Gallons Per Dwelling/Unit Per Day
Single-Family Residential	55.2	29-39	341-453
Duplex-Triplex	2.8	18-26	191-233[3]
Multi-Family Residential	10.3	17-23	200[4]
Commercial	18.8	33-36	-
Industrial	3.7	40-48	-
Unaccounted for	9.2	-	(2,600 gal./main-mile)
TOTAL	100.0	30-37[1] 26-39[2]	

[1]From billing records:

$$[1- \frac{(\text{Feb. billing (100 c.f.)} + \text{Mar. billing (100 c.f.)} \div 60}{\text{annual billing (100 c.f.)} \div 365}]$$

[2]From pumping records: defined as

$$[1 - \frac{\text{Ave. Jan.-Feb. pumping rate (mgd)}}{\text{Ave. annual pumping rate (mgd)}}]$$

[3]Based on an assumed 2.5 Dwelling-unit per Duplex-Triplex
[4]Estimate based on 2 years (1975: 190, 1978: 195)

fixtures. For example, the relevant unrestricted water use for the single-family residential (domestic) sector in 1990 is 31.4 mgd less 24.4 mgd or 7.0 mgd. It is this additional water use to which this measure applies.

The fraction reduction in use is estimated from the more detailed analysis performed for Atlanta. It is taken as 0.23 for residential domestic uses, as 0.15 for commercial uses, and negligible for all other uses. Coverage is assumed to be 0.95, thus allowing for exemptions and violations. Table 79 gives the resulting estimates of effectiveness for single-family and multi-family residential sectors, and for the commercial sector. Total effectiveness is seen to increase from zero in the base year to 11.1 mgd by the year 2030.

Measure T2--Change in Price Structure

This water conservation measure requires a seasonally differentiated price structure for both water and wastewater services, without blocking. The summer (May-October) price is to be set equal to the expected level of the incremental cost of seasonal use. The winter (November-April) price is set at a level such that average annual price for nonseasonal use is equated to the expected incremental cost of nonseasonal supply.

The incremental cost of seasonal use includes all costs associated with average day use, consumptive use, and maximum day use. Maximum day costs are allocated evenly to the days in the summer period adjusted by the probability that the peak will lie within the period (which in this case is judged to be virtually 100 percent). Using values determined in the evaluation section to follow, the incremental cost of base year changes in average day water use can be found equal to ($100,380 + $14,230 + $149,270 + $66,800), or $330,680/mgd (average). The incremental cost of changes in maximum day water use is ($73,700 + 0.5 * $56,200) or $101,800/mgd (maximum day). It is assumed here that increases in seasonal use increase maximum day use by an amount 1.5 times the increase in the level of the average day of the maximum month. The summer price of water is calculated at 0.000748 * ($101,800/182 + $330,680/365) = $1.10/100 c.f.

The incremental cost of nonseasonal use is the sum of the average day and sewer contribution costs distributed over the year. Again, using values developed as part of the latter evaluation:

$$0.000748 * [(\$330,680 + \$15,000 + \$15,750 + \$16,000 - \$22,400)/365]$$

which equals a desired annual average price of $0.73/100 c.f. If the summer price is $1.10/100 c.f., the winter price would be $0.36/100 c.f. This change in pricing policy would be accompanied by a publicity campaign similar to the one now associated with the "Beat the Peak" Campaign.

Adjustments would undoubtedly be needed in order that the new rate structure provide the required total revenue. So that the marginal cost basis of the rates is not distorted, these adjustments should be accomplished inframarginally. For example, if the new rates, unadjusted,

TABLE 79

CUMULATIVE SAVING IN WATER USE FROM PLUMBING CODE CHANGE (MGD)

Unit	1980	1990	2000	2010	2020	2030
Single-Family	0	1.5	3.0	4.3	5.5	6.8
Multi-Family	0	0.4	0.9	1.2	1.6	2.0
Commercial	0	0.5	1.0	1.5	1.9	2.3
Total Cumulative	0	2.4	4.9	7.0	9.0	11.1

produce too little revenue, a fixed service charge can be added to each bill, large enough to increase total revenue to the desired level. Conversely, if the marginal cost rates produce too much revenue, a credit can be allowed against individual bills, or the first few units of water use can be offered at a lower price. It is important, however, that substantially all customers face the full marginal cost price at the margin of their individual consumption.

Calculating the effectiveness of the revised rates would require setting up a new system of user sectors, where each existing sector is subdivided into additional sub-sectors, one for each group of customers who pay a particular rate from the present rate schedule. Using estimates of the price elasticity of demand for various user types, the fraction reduction in water use can be estimated for each sub-sector, depending upon the price change actually experienced by users in that sub-group. This figure, when multiplied by the unrestricted water use for that sub-group and by the coverage (100 percent), yields the effectiveness for the sub-sector, which can be aggregated across all sub-sectors.

It was not possible, within the constraints of this study, to determine unrestricted water use forecasts for the number of sub-sectors made necessary by Tucson's rather complex rate structure. Instead, it is assumed with a single exception (residential rates in summer) that all water users within each of the sectors listed on Table 78 face the same, seasonally differentiated prices. The assumed price levels are shown on Table 80. Effectiveness calculations, therefore, require only the data given on Tables 77 and 80, the proposed prices calculated above, and estimates of price elasticity (shown as Table 81). For residential and

TABLE 80

HYPOTHETICAL RATE STRUCTURE FOR TUCSON

	Rate for Water and Wastewater Service ($/100 c.f.)	
	Winter[1]	Summer
Single-Family Residential (less than 20 100 c.f./month	1.60	0.70
Single-Family Residential (20 100 c.f./month and more)	1.60	1.00
Multi-Family Residential	1.45	0.65
Commercial	1.45	0.60
Industrial	1.35	0.55

[1] Effective marginal price is higher in winter since existing wastewater charges apply to winter use only.

TABLE 81

ASSUMED PRICE ELASTICITIES OF DEMAND: TUCSON

	Nonseasonal Use	Seasonal Use
Single-Family Residential	-0.3	-0.6
Multi-Family Residential	-0.15	-0.3
	Winter Use	Summer Use
Commercial	-0.2	-0.3
Industrial	-0.4	-0.4

commercial sectors, a three-year adjustment to new prices is assumed. Industrial customers are assumed to require four years for a complete adjustment.

The fraction reduction in water use for each sector is found by the following expression:

$$R_{ijt} = \left[1 - \left(\frac{P_2}{P_1}\right)^n\right]$$

Where: P_1 = price faced by users in sector j at time t, <u>without</u> change in price structure

P_2 = price faced by users in sector j at time t, <u>with</u> change in price structure

n = price elasticity of demand for sector j at time t.

Applying this expression to the various sectors and seasons, and assuming that single-family residential water users exceed 20 100 c.f./month during the summer with a frequency such that customers accounting for 20 percent of all summer water used by that sector face the higher summer price, the values shown on Table 82 can be calculated. It is assumed that residential non-seasonal use responds to average annual price. Reduction in maximum day water use is calculated as 1.8 times reduction in summer season water use (expressed as mgd). Table 82 assumes that real price levels do not change throughout the planning period. In practice, prices would be revised periodically as cost conditions change.

<u>Measure T3--*Subsidized Loans for Landscape Changes*</u>

Since this measure applies only to existing residential properties, no forecasts of water use are required for its analysis. The unrestricted water use affected is the seasonal water use of the 60,000 residential properties now landscaped with humid-climate vegetation. This is estimated at 12.0 mgd for 1980. Adoption of desert vegetation is expected to reduce water use by these properties by an amount equal to 0.80 times seasonal use. A total of five percent of all such properties would be affected, according to the assumptions given above. Total effectiveness would be, therefore, 0.48 mgd reduction in average day water use and 1.73 mgd reduction in maximum day water use (1.8 times reduction in summer water use). This effectiveness would be realized over a ten-year period, being equal to 0.048 mgd in 1981, 0.096 mgd in 1982, 0.144 mgd in 1983, and so on.

ADVANTAGEOUS EFFECTS

<u>Measure T1--Plumbing Code Change</u>

The plumbing code change described would result in decreased use of water for toilet flushing and for showers in affected residences. Since

TABLE 82

EFFECTIVENESS OF MEASURE T2 (PRICE CHANGE): TUCSON

Sector	Water Use Reduction (MGD)								
	1980	1981	1982	1983	1990	2000	2010	2020	2030
Single-Family Residential									
Winter	(1.26)[1]	(2.59)	(3.99)	(4.10)	(4.86)	(5.89)	(6.79)	(7.70)	(8.60)
Summer	0.50	1.03	1.59	1.62	1.94	2.35	2.71	3.04	3.42
Annual	(0.38)	(0.78)	(1.20)	(1.24)	(1.46)	(1.77)	(2.04)	(2.33)	(2.59)
Multi-Family Residential									
Winter	(0.13)	(0.27)	(0.42)	(0.43)	(0.51)	(0.62)	(0.71)	(0.81)	(0.90)
Summer	0.05	0.09	0.14	0.15	0.19	0.22	0.25	0.27	0.32
Annual	(0.04)	(0.09)	(0.14)	(0.14)	(0.16)	)0.20)	(0.23)	(0.27)	(0.29)
Commercial									
Winter Summer	(0.90)	(1.83)	(2.83)	(2.90)	(3.47)	(4.18)	(4.82)	(5.46)	(6.11)
Summer	0.95	1.97	3.04	3.12	3.69	4.46	5.15	5.85	6.52
Annual	0.03	0.07	0.11	0.11	0.11	0.14	0.17	0.20	0.21
Industrial									
Winter	(0.24)	(0.49)	(0.76)	(1.05)	(1.25)	(1.53)	(1.67)	(1.95)	(2.23)
Summer	0.22	0.45	0.69	0.95	1.11	1.36	1.60	1.79	1.99
Annual	(0.01)	(0.02)	(0.04)	(0.05)	(0.07)	(0.09)	(0.04)	(0.08)	(0.12)
Public & Unaccounted[2]									
Winter	(0.13)	(0.26)	(0.41)	(0.43)	(0.51)	(0.62)	(0.71)	(0.81)	(0.91)
Summer	0.09	0.18	0.28	0.30	0.35	0.43	0.50	0.56	0.62
Annual	(0.02)	(0.04)	(0.07)	(0.07)	(0.08)	(0.10)	(0.11)	(0.13)	(0.15)
Average Day Water Use	(0.42)	(0.86)	(1.14)	(1.39)	(1.66)	(2.02)	(2.25)	(2.61)	(2.94)
Maximum Day Water Use[3]	3.26	6.70	10.33	11.05	13.10	15.88	18.38	20.72	23.17
Average Day Sewer Contribution	(2.66)	(5.44)	(8.41)	(8.91)	(10.60)	(12.84)	(14.70)	(16.73)	(18.75)
Maximum Day less Average Day of Maximum Month[4]	1.09	2.23	3.44	3.68	4.37	5.29	6.13	6.91	7.72

[1] Parentheses indicate increase in water use
[2] --50% of public and unaccounted use assumed due to meter misregistration
[3] --Change in maximum day water use equal to 1.8 times change in summer season water use
[4] --Equal to 0.6 times summer season water use

much of the water used for showers must be heated, a reduction in the quantity of hot water used brings about a reduction in the quantity of energy required to heat water. Sharpe (undated) estimates savings of approximately $29.00/year (Dec. 1978 dollars) per household affected, based on shower flow reductions similar to those considered here. Assuming 1,500 new dwelling units per year affected by the new plumbing code, the advantageous effect increases on a uniform gradient of $43,500 per year. At the 6.875 discount rate, this yields a present value of $8,343,000. Annualizing this figure gives $595,000/year as the equivalent advantageous effect over the planning period.

Measure T2--Change in Price Structure

A change in the price structure for any commodity affects the level of use, and hence the net satisfaction (consumer surplus) obtained from use. For a product such as water, where there are no close market substitutes, a move to an incremental cost based price schedule (marginal cost pricing) can be shown to increase consumers' surplus, provided that the water utility obtains total revenue equal to total cost both before and after the change. If price had previously been above marginal cost, lowering it would increase users' total satisfaction more than it would increase the costs which they must bear; where the previous price was lower than marginal cost, increasing it would reduce consumers' costs more than it would reduce total satisfaction. Either type of change would increase net satisfaction. Quantification of the increased net satisfaction attributable to marginal cost rates requires sufficient econometric analysis to identify the relevant portions of demand curves for all classes of users. This analysis was not performed as a part of this study, so no quantitative estimate of the value of increase consumer satisfaction is available. Based on economic theory, however, a positive, though unquantified advantageous effect is expected.

Measure T3--Subsidized Loans for Landscape Changes

This measure, to the extent that it is implemented, will change the visual appearance of residential neighborhoods in the city. This may be interpreted as a disadvantageous, or as an advantageous effect, depending upon the preferences of the viewer. A well managed educational effort conducted in conjunction with the loan program may be successful in making many residents of Tucson aware of the attractive aspects of desert vegetation so that many, if not most residents, will come to see this change as an advantageous effect. The significant number of properties which have already changed landscape materials, and the near-universal use of these materials on newly developed properties, suggest that prior efforts to popularize this measure have been effective. An increase in the number of properties employing desert vegetation, therefore, is assumed to provide an advantageous effect with respect to the quality of the urban environment.

DISADVANTAGEOUS EFFECTS: IMPLEMENTATION COSTS

Measure T1--Plumbing Code Change

No data were found which would support estimate of the administrative cost of initiating, enacting, and implementing changes in an existing plumbing code. Incremental costs (over and above those that would be associated with the present code) are likely to be small. In particular, implementation and enforcement costs are assumed negligible, since existing administrative and enforcement systems would be used. It also appears that costs borne by builders or home buyers would be negligible, since the cost of the water saving fixtures is essentially identical to that of conventional units.

Measure T2--Change in Price Structure

Implementation of a new rate structure would require a marginal cost of service study to provide the basis for the rates themselves. The estimated cost of a complete rate study is $75,000, a one-time cost borne by the two affected agencies. No further costs are anticipated, since subsequent changes would be similar to those required by present rate structures. When annualized over the planning period at a discount rate of 6.875 percent, the implementation cost of this measure is equivalent to $5,350 per year. This assumes implementation in the base year (1980).

Measure T3--Subsidized Loans for Landscape Changes

The subsidy granted homeowners who re-landscape results from the fact that bonds issued by the city to finance the program are tax-exempt: Purchasers of the bonds are not required to pay Federal income tax on interest payments. The implementation of this program, therefore, results in diminished tax payments to the Federal government. This cost is ultimately borne by all taxpayers throughout the country in the form of marginally increased Federal tax levels. If it is assumed that interest costs of the program are reduced by five percentage points due to the tax exemption, the implementation costs include an amount equal, during any year, to five percent of the outstanding principal of all bonds issued by the city to finance the program.

The major implementation costs, however, are borne by the participating residents, who face the full cost of landscape renovations with the single exception of the interest subsidy. Since the interest subsidy is borne by others (taxpayers in general), the total implementation cost is the cost borne by participating residents plus the cost borne by taxpayers: It is equal to the cash outlay which residents would incur if the loans were financed at commercial rates. However, the number of participants is a function of the subsidized rates, not the full cost.

It is assumed that the average residential lot in Tucson includes 5,000 square feet of irrigable area. Redesign would consist of replacing bermuda grass and existing shrubbery with a gravel base, drought resistant shrubbery, and cacti. Telephone interviews with Tucson

landscape contractors indicate that the summer, 1979, cost of such changes would be in the range of $1.40 to $2.20 per square foot, or $7,000 to $11,000 for a 5,000 square foot plot. Based on the assumed adoption rate of 300 properties per year, and using a mid-range cost estimate, implementation costs are taken as $9,000 times 300, or $2.7 million per year. In this case, the first cost of re-landscaping a given property is treated as equivalent to the present value of the full social cost of implementation (cost borne by resident plus subsidy). At a discount rate of 6.875 percent, and a ten-year program life, these costs are equivalent to a present value of $19.07 million, or an annualized value of $1.36 million per year for the full planning period.

OTHER DISADVANTAGEOUS EFFECTS

Measure T1--Plumbing Code Change

A potential disadvantageous effect of this measure might be consumer dissatisfaction with the performance of the fixtures. Some persons may feel that the 3.5 gpm shower flow is not satisfactory, although rinsing effectiveness and tactile sensation are more likely to be a function of shower head design than flow. The 3.5 gal/flush toilets may not provide the same flushing action, contributing to consumer dissatisfaction. At present, the magnitude of these adverse reactions is unknown and would require further studies of actual home installations and subsequent interviews with residents.

Measure T2--Change in Price Structure

No other disadvantageous effect is anticipated.

Measure T3--Subsidized Loans for Landscape Changes

No other disadvantageous effect is anticipated.

CHAPTER IX

EVALUATION OF WATER CONSERVATION MEASURES

Advantageous effects of water conservation measure consist principally of costs foregone. Reducing water use has the effect of reducing both water supply and wastewater disposal costs. Further, where water use creates external costs for parties other than the water supplier and the water users, these external costs may be reduced as well.

This section describes the identification and measurement of short-run and long-run incremental costs likely to be affected by changes in water use. External costs are also analyzed and measured where possible. All supply-cost use reduction relationships are assumed linear over the relevant range, and the necessary coefficients are estimated. Application of these relationships to the effectiveness estimates developed in the previous section results in estimates of the advantageous effects expected to result from the implementation of the water conservation measures analyzed.

Where water conservation measures are to be considered as an element of a Federal water supply/conservation plan, some of the costs to be analyzed will be those of the Federal plan. Since several alternative Federal plans are usually evaluated (e.g., the NED plan, the EQ plan, the primarily nonstructural plan, etc.), a cost analysis must be performed for each plan. Each conservation measure, in this case, will be associated with several alternative advantageous effect measures: a value which assumes that the NED plan is implemented; a value which assumes that the EQ plan is implemented.

In the case of this illustrative example, no Federal water supply plans were under consideration. Water conservation advantageous effects depend entirely on local plans and facilities. Accordingly, a single estimate of advantageous effects is prepared for each water conservation measure considered.

SHORT-RUN INCREMENTAL SUPPLY COSTS

Water Supply

There are two types of short-run supply costs for Tucson: (1) pumping costs and (2) the increase in future pumping costs due to lowering the water table. The incremental pumping cost is determined by the cost of the wells used last: those with the highest operating costs. The wells which accounted for the most expensive 8.7 mgd for the period June 1978-May 1979 averaged $0.224/1,000 gallons pumping cost. [The average cost over the next increment of 5.5 mgd was $0.130/1,000 gallons.] Booster costs were $0.051/1,000 gallons which, when added to well costs, give an incremental pumping cost of $100,380/mgd/year over the first 8.7 mgd.

It is projected that for 1979 the major water tables (Southside Central and Santa Cruz) will decline by an average of 4 to 6 feet/year from a current level of approximately 200 feet below the surface. This increase in lift will cause an increase in total well pumping costs next year and each year thereafter from \$50,000/yr. to \$75,000/yr. (calculated as 2-3 percent change in depth times 1978-1979 pumping costs). For average annual pumpage of 60 mgd, this increase is \$833-1250/mgd, or \$1,040 ± 110/mgd. Since this increment would be added to cumulative pumping costs each year, the present value of all such future increases can be estimated as that of a uniform gradient, using the factor

$$\frac{(1 + R)^{t+1} - (1 + tR + R)}{R^2 (1 + R)^t}$$

Where: R = discount rate

t = planning period.

When the discount rate is 6.875 percent, and the planning period is 50 years, this factor is equal to 191.802. The present value of future changes in pumping costs resulting from a sustained reduction in water withdrawal is, therefore, \$199,470 ± 21,100/mgd. When annualized over 50 years, this amount of \$14,230 ± 1,500 mgd-year.

For sustained reductions beginning after the base year, both values derived above are adjusted by:

$$\left[1 - \left(\frac{1 - 1.06875^{-k}}{0.964}\right)\right]$$

Where: K = year of first reduction in water use.

Wastewater Disposal

The average cost of the sewer operation, maintenance and repair items which are most likely viable with flow (utilities and chemicals) has ranged from \$0.012/1,000 gallons (sewer flow) to \$0.022/1,000 gallons (Dec. 1978 \$). Adding salaries for treatment plant operation and sewer maintenance raises the average variable cost to a range of \$0.058 to \$0.071 per 1,000 gallons. Regressions on five years of such data yield unsatisfactory results (nonsignificant coefficients). Thus the estimated value of use reduction in terms of short-run saving of sewer cost is estimated at \$15,000 ± \$11,000/mgd (sewer contribution)-year, based on clearly variable items as a lower bound and variable items plus non-administrative salaries as an upper bound.

LONG-RUN INCREMENTAL SUPPLY COSTS

Water Supply

The most significant planned water supply improvement in the Tucson

area is the Central Arizona Project (CAP) and associated water treatment and transmission. This project is intended to reduce the rate of groundwater depletion. A lowered rate of use would lower the rate of depletion and allow the Tucson Aqueduct portion of the CAP to be delayed while maintaining the same quality of service. This can be seen from Figure 23. The lower line represents the planned path of groundwater depletion without additional conservation. With conservation the CAP can be delayed until ground water reaches the same level as the change in slope of the upper line.

The saving from this delay represents a lower bound estimate of the benefits of conservation since the level of depletion and the associated potential problems of subsidence and water quality are less in every year under the conservation scenario. The estimate is also a lower bound in another sense. With conservation, officials may, in fact, decide *not* to delay the projects. This would indicate that the benefits from reduced depletion are judged greater than the potential cost savings. Thus the change in the present value of cost associated with delaying the CAP until the same level of depletion is reached constitutes a minimum estimate of advantageous effect.

The construction cost for Routes II, VI, and VIII of the Tucson aqueduct portion of the CAP is estimated (at Jan. 1979 prices) at $210 million; operating costs, beginning in 1987, are $7.242 million/year. In addition to these costs, water provided to Tucson must be pumped through the upstream portions of the CAP. At the initial 49.1 mgd rate, this cost is estimated as:

$$1{,}296 \text{ ft. (dynamic head)} * 49.1 \text{ mgd} * \frac{1.547 \text{ cfs}}{\text{mgd}} * \frac{0.0846 \text{ kw}}{\text{cfs-ft}} *$$

$$\frac{1}{0.80} \text{ (efficiency)} * \frac{\$0.016}{\text{kw-hr.}} * \frac{24 \text{ hr.}}{\text{day}} * \frac{365 \text{ days}}{\text{yr.}} =$$

$1.46 million/year.

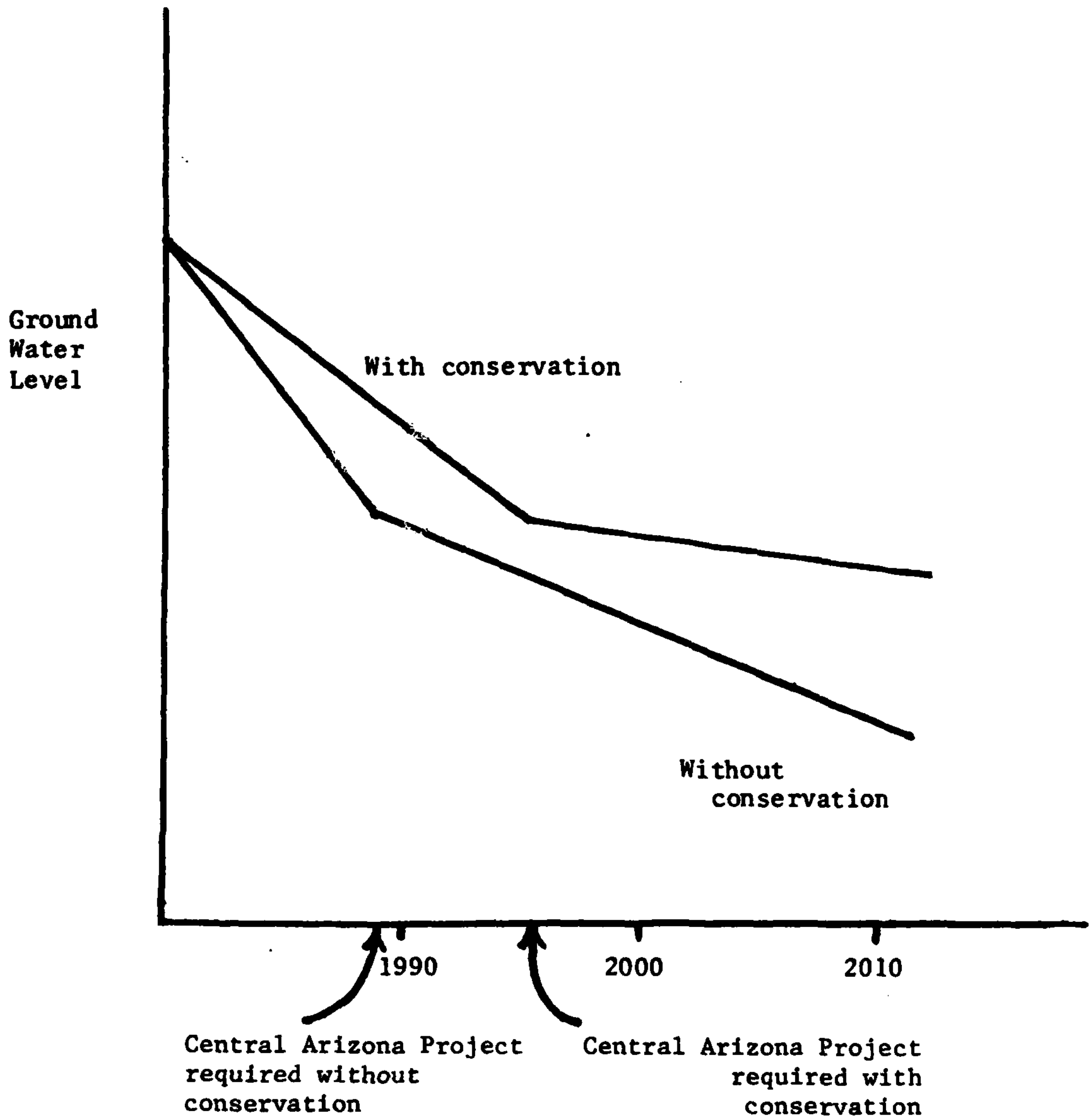
When all these costs are discounted to the base year at 6.875 percent, they have a combined present value of $206.77 million.

The projected cost of the 90 mgd water treatment plant, together with necessary transmission lines and reinforcement of the northern end of the existing distribution system, is $61.3 million, with operating costs of $3.99 million/year. The present value of these amounts in the base year if $72.8 million. This gives a total present value cost of the CAP project of $206.77 million plus $72.8 million, or $279.57 million.

The average rate or recharge is assumed to be approximately 20 mgd for the aquifers used by the City of Tucson. The City has projected average day water use for 1987 at 82 mgd. A sustained savings of 1 mgd for the next seven years avoids the equivalent of 0.113 years of depletion, at the 1987 rate. The value of postponing a $279.57 million investment for 0.113 years $\left(1 - \left(\frac{1}{1.06875}\right)^{0.113}\right)$ times $279.57 million,

FIGURE 23

GROUNDWATER DEPLETION AS A FUNCTION OF
WATER CONSERVATION



or $2.093 million.

The long-run incremental cost savings attributable to a water conservation measure beginning in the base year is, therefore, $2.093 million/mgd (average day), or $149,270/mgd (average day)-year. If the measure is implemented after the base year, but before the seventh year, the exponent in the previous calculation (0.113) must be altered accordingly. Its value is reduced by 0.016 for each year (after the base year) delay before the start of implementation. Water conservation measures beginning after year 7 provide no benefits of this type, as they would not delay the construction of the CAP, given the assumptions used here.

The CAP will be utilized to the maximum extent possible to replace groundwater pumping by the City of Tucson. As long as use remains above the level of CAP deliveries (projected to be 49.1 mgd in 1987 and 87.5 mgd in 2034) the costs associated with the CAP are not affected by use. Among the capital costs affected by water use are those associated with well drilling and transmission of groundwater. Black and Veatch (1977) estimated two alternative capital improvement programs: the first based on projected maximum day use, the second based on approximately 30 mgd reduction in maximum day use. The difference in present value between these two programs at 6.875 percent is $23.1 million (1979 $). Annualizing this value and distributing over the 30 mgd (maximum day) yields a value of $54,800/mgd (maximum day)/year. This value applies to reduction in use before 1987 since the well fields in question would not be expanded after the CAP is available.

Other projects will be required in spite of the CAP, however. The displacement in time of a project in the Central Avra Valley now projected for 1995, yields an additional $18,900/mgd (maximum day)/year attributable to water use reductions beginning before 1995. This gives total incremental costs of $73,700/mgd (maximum day)/year for sustained reductions beginning before 1987, and $18,900 mgd (maximum day)/year for reductions beginning after 1987, but before 1995.

It is estimated that the current use of 60 mgd leads to a loss of 6 mgd of well capacity each year (Johnson, 1978). A sustained reduction of 1 mgd (beginning in 1980) will preserve 0.7 mgd of capacity by 1987 when the North Avra Project is projected to be needed. It allows a delay equivalent to that achieved by a 0.7 mgd reduction in peak use. The value of such a delay is 0.8 mgd * $54,800/year or $38,400/mgd/year over the 50-year time horizon (see above). Similarly by 1995, 1.5 mgd of capacity is preserved to delay the Central Avra Project for a foregone cost of ($18,900/mgd/year * 1.6 mgd) or $28,400/year over the 50-year time horizon. The annualized value of a sustained reduction of one mgd begun now is $66,800/year. For the period from the base year until 1987 the annualized value of sustained reductions is reduced by $7,380 for each year of delay. Between 1987 and 1995 the annual reduction is $1,890 per year delay.

There are strong indications that the relevant design parameter for staging well capacity is or will soon be changed to the average daily use in the maximum month rather than maximum day. Variations in use within

the maximum month will be met from finished water storage. This changes the use variable of the costs derived above to average use in the maximum month. This also allows calculation of the relationship between use and finished water storage costs. The method of determining the desired volume (V) of storage is given by

$$V = (\text{Max. Day} - \text{Ave. Day Max. Mo.}) * 1.5 * \text{days}$$

(source: "Assumptions Associated with the Metropolitan Tucson Water Concept Plan")

The current (1979) bid for storage capacity is 14.5¢/gallon. As long as maximum day use is growing the following expression gives the annualized advantageous effect attributable to reduced storage costs from a change in use (at 6.785 percent for 50 years).

Annualized Foregone Cost = $56,200/mgd (Max. Day - Ave. Day Max. Mo.) - year

Wastewater Disposal

Bids were opened (Aug. 1979) for a major renovation of the Rogers Road Sewage Treatment Plant. The renovation includes expansion of the plant capacity. This investment cannot be delayed by reducing sewer contributions. Two other expansions, $3.5 million in 1990 and $10.8 million in 2015, are planned for the 50-year planning period. Only 50 percent and 67 percent, respectively, of these investments are judged to be water use related, but their timing is assumed to be determined by sewer flow.

In 1990 water use is projected to increase at a rate of 1.94 mgd/year. Of this increment, 62 percent is estimated nonseasonal use contributed to the sewer (33 percent seasonal, 5 percent lost in distribution.) A sustained 1.0 mgd reduction in sewer contribution which begins before 1990, therefore, could postpone the planned investment of 0.83 years (1/(.62 * 1.94)). The difference in the present values of the planned investment is $96,700. The annualized equivalent of this amount, $6,900/mgd (sewer contribution)-year, is the incremental cost avoided by water use reductions occurring before 1990.

In 2015, the projected growth rate in water use is 1.63 mgd/year, of which 65 percent is nonseasonal. Using the same method, a sustained 1.0 mgd reduction in sewer contribution occurring before 2015 could postpone the planned investment 0.94 years, giving a difference in the present value of the investment of $124,100. The incremental cost avoided by reductions before 2015, therefore, is $8,850/mgd (sewer contribution)/ year. Combining these estimates gives a total cost reduction of $15,750/mgd (sewer contribution)/year for use reductions beginning before 1990, and $8,850/mgd (sewer contribution)-year for those beginning in 1990 or later, but before 2015.

Over the period 1980-1983 sewer transmission expansions are projected to cost an average of $1.95 million/year. It is assumed that reductions in sewer contributions would permit this investment program to

be deferred. It is further assumed that, once complete, this investment program will provide sufficient transmission capacity for anticipated future flows from presently served areas. During the 1980-1983 period total water use is expected to increase at the rate of 2.24 mgd/year. If 62 percent of this growth is accounted for by water returned to the sewer, sewer contributions will increase at an annual rate of 1.39 mgd/year. A sustained reduction occurring in 1980, therefore, would postpone the subsequent three years' investments by 0.72 years. This would provide a present worth saving of $224,340/mgd (sewer contribution). A reduction beginning in the second year would affect only two years' investment, giving a saving of $144,530/mgd (sewer contribution); and a reduction beginning in the third year would save $74,670/mgd (sewer contribution). The annualized equivalents of these amounts, all expressed as $/mgd (sewer contribution)/year, are $16,000, $10,310, and $5,330, respectively.

EXTERNAL OPPORTUNITY COSTS

Downstream Irrigation

Water that is used but not consumed by the city of Tucson is discharged into the dry bed of the Santa Cruz River. This water eventually percolates "downstream" to the Cortaro-Marana Irrigation District, where it is withdrawn and used for crop irrigation. The opportunity cost of water not discharged is the net value of the water in its alternative use, which has been estimated for Arizona agriculture at $20/acre-foot (Barbera, 1978) or $22,400/mgd (consumer)/year.

This cost appears whenever water which would otherwise be discharged to the sewer is, instead, not used or used and consumed. The cost is foregone (an advantageous effect appears) when sewer flow is increased. It appears, therefore, as an offset to advantageous effects associated with reductions in sewer contribution.

In determining the opportunity cost it is immaterial that the farmers do not pay for the water. The water which is consumed imposes an additional cost beyond the cost of extracting it from the ground in that it cannot be used for growing crops; the incremental value it would have contributed is foregone.

Upstream Uses

Wildlife and recreation benefits in the Santa Cruz are no longer related to the levels of pumping since the water table is several hundred feet below the surface. This places it well out of reach of riparian vegetation. Incremental changes in water use would have no effect on vegetation. In other areas such as the Avra Valley there is the possibility that incremental changes in use can affect wildlife either by delaying or decreasing the amounts of groundwater pumpage.

There are also external costs which continued drawndown would impose on the farmers in the Green Valley-Continental areas of the South Santa

Cruz Valley. Falling water table elevations increase required pumping capacity. The complex hydrology makes it very difficult to estimate the magnitude of these costs but they are probably less than the costs of this type that Tucson imposes on itself (see above).

Ground Subsidence

The increased potential for ground subsidence in the urbanized areas of Tucson as a result of water use is a serious matter. It could well be that this type of cost could be larger than all the other costs combined. On the other hand, if another several hundred foot drop in water table does not cause substantial subsidence then equilibrium may be achieved before any damage is done. Even though municipal use is a small fraction of total use in Eastern Pima County (15 percent), it is almost the sole use of the Central (interior) well field where the consequences of subsidence would be most serious. Data do not presently exist which would support estimates of the expected advantageous effect of reduced risk of subsidence.

MEASUREMENT OF FOREGONE SUPPLY COSTS

Supply Cost/Water Use Reduction Relationships

The relationships developed in the preceding sections are summarized on Table 83. Those related to short-run incremental supply costs derive from the analysis of marginal pumping costs associated with within-period withdrawal, and those attributable to falling water tables and consequent higher future pumping costs. Changes in wastewater disposal costs are also reviewed. Relationships derived from analysis of long-run incremental supply costs include those associated with the timing of the Central Arizona Project and ancillary works, those associated with the timing of various local well field developments, and those associated with the requirement for finished water storage. Both wastewater treatment capacity and transmission capacity costs are found to be affected by sewer contributions. Several categories of external opportunity costs are reviewed, but only those associated with loss of water for downstream irrigation provide a monetary measure.

All incremental costs are stated as annualized values over the full 50-year planning period, at a discount rate of 6.875 percent. In every case, it is assumed that a water use reduction, once begun, is sustained until the end of the period. Incremental costs shown in the table, unless otherwise stated, refer to water use reductions beginning in 1980. When later implementation would reduce or eliminate the cost savings, appropriate notations are provided. The costs shown are additive. If a water conservation measure implemented in the base year reduced average day water use, maximum day water use, and sewer contribution by equal increments, the total cost savings per mgd reduction is found by summing all related table entries. For example, average day reductions are \$100,380 + \$14,230 + \$149,270 + \$66,800 = \$330,680/mgd; maximum day reduction is \$73,700; and sewer contribution reductions are \$15,000 + \$15,750 + \$16,000 - \$22,400 = \$24,350/mgd. The total cost savings is \$428,730/mgd for reductions beginning in 1980.

TABLE 83

SUMMARY OF SUPPLY COST/WATER USE REDUCTION RELATIONSHIPS: TUCSON

Cost Category	Water Use Unit	Annual Cost Saving per unit in dollars (50 years @ 6.875%, in 1979 prices)
SHORT-RUN INCREMENTAL SUPPLY COSTS		
Water pumping	1 mgd average day	100,300[1]
Falling water tables	1 mgd average day	14,230 ± 1,500[1]
Wastewater disposal	1 mgd sewer contribution	15,000 ± 11,000[1]
LONG-RUN INCREMENTAL SUPPLY COSTS		
Central Arizona Project	1 mgd average day	149,270[2]
Well capacity (increased use)	1 mgd maximum day	
(implementation 1980-1986)		73,700
(implementation 1987-1994)		18,900
Well capacity (drawdown)	1 mgd average day	66,800[3]
Finished water storage	1 mgd (maximumm day-ave. day in max. month)	56,200[1]
Wastewater treatment	1 mgd sewer contribution	
(implementation 1980-1989)		15,750
(implementation 1990-2014)		8,850
Wastewater transmission	1 mgd sewer contribution	
(implementation 1980)		16,000
(implementation 1981)		10,310
(implementation 1982)		5,330
EXTERNAL OPPORTUNITY COSTS		
Irrigation	1 mgd sewer contribution	22,400[1]

[1] For implementation in 1980; if implementation occurs in later years, value is adjusted by multiplying by:

$$1 - \frac{1 - 1.06875^{-k}}{0.964}$$

where k is the first year of implementation (k=0 for 1980).

[2] For implementation in 1980; if implementation occurs in later years, value is re-calculated as shown in text. No cost saving for implementation after 1987.

[3] For implementation in 1980; if implementation occurs in later year, cost saving is reduced by $7,380 for each year delay until 1987, and by $1,890 for each year thereafter. No cost saving for implementation after 1995.

FOREGONE SUPPLY COST ESTIMATES

The following sections outline the calculations of annualized advantageous effects for each of the water conservation measures under consideration. In each case, advantageous effects are calculated on the basis of effectiveness measures determined in the preceding sections, using supply cost/water use reduction relationships from Table 83.

Measure T1--Plumbing Code Changes

The water use changes calculated for implementation of a plumbing code affecting new construction refer to nonseasonal use, residential and commercial sectors. They will appear as equal increment reductions in maximum day water use, maximum month water use, average day water use, and sewer contribution. The difference between maximum day and average day of the maximum month is unaffected. Water use reduction in the base year would, therefore, result in annualized foregone costs equal to $438,730/mgd/year ($129,610/mgd for short-run costs, $321,520/mgd for long-run costs, and a deduction of $22,400/mgd for external costs). These foregone costs reduce gradually for later implementation dates, as shown on Table 83. Table 84 gives the values associated with selected implementation dates in the second, third, and fourth columns.

The cumulative effectiveness of the plumbing code change, taken from Table 79, is given in the fifth column of Table 84 with necessary interpolation. In order to simplify the calculation, it is assumed that effectiveness increases discontinuously, with new increments appearing only in the years actually shown in Table 84. The sixth column shows the incremental change in effectiveness. Columns seven, eight, and nine give the annualized foregone cost attributable to each increment of effectiveness. The sums of the entries in these columns are the annualized foregone costs attributable to this water conservation measure; they total $684,900/year.

Measure T2--Change in Price Structure

The adoption of marginal cost based rates by the Tucson water utility would result in changes in the structure and level of water use in a given year, and changes in the rate of increase of water use over time. Table 82 presents estimates of the effectiveness of a marginal cost based rate structure, based on comparison with a hypothetical existing rate structure, one that omits the increasing block feature now used by Tucson. The effectiveness calculated would result in cost savings, compared to costs that would be incurred if the hypothetical rate structure were in force. The cost savings are attributable to reductions in average day water use, maximum day water use, maximum month water use, average day sewer contribution, and the excess of maximum day over maximum month use. Each of these changes affects some category of incremental cost, as summarized on Table 83.

To the extent that cost savings accrue to the water and wastewater utilities, and are then passed on to water users in the form of lower total revenue requirements, they are not necessarily countable as

TABLE 84

BENEFIT CALCULATIONS FOR MEASURE T1

Year	Annualized cost saving (DOLLARS PER MGD)	Cumulative Effectiveness (MGD)	Incremental Effectiveness (MGD)	Annualized Benefit (DOLLARS PER MGD)
0	428,730	- 0 -	- 0 -	- 0 -
1	387,830	0.24	0.24	93,080
2	347,290	0.48	0.24	83,350
3	307,210	0.72	0.24	73,730
6	205,120	1.44	0.72	147,690
7	115,620	1.68	0.24	27,750
8	109,230	1.92	0.24	26,200
9	105,030	2.16	0.24	25,210
10	90,420	2.40	0.24	21,700
14	68,500	3.40	1.00	69,500
15	45,860	3.65	0.25	11,470
16	43,230	3.90	0.25	10,810
20	34,260	4.90	1.00	34,260
30	19,980	7.00	2.10	41,960
34	16,450	7.80	0.80	13,160
35	6,850	8.00	0.20	1,370
40	3,780	9.00	2.00	7,560
50	- 0 -	11.10	2.10	- 0 -
Total				688,820

advantageous effects. Economic theory shows that setting prices equal to marginal costs maximizes the sum of consumers' surplus and producer's surplus. Since municipally-owned utilities do not ordinarily accumulate losses or retain or distribute profits, producer's surplus is presumably zero. Consumer's surplus (the excess of aggregate willingness-to-pay over total amount paid) is therefore maximized. In some cases, changing the prices may reduce willingness-to-pay, but if the revenue collected is reduced by a larger amount the surplus is still increased. There is no convenient way to determine the extent to which reductions in total revenue collected may be partially offset by reductions in willingness-to-pay. It can only be claimed that the net effect will be positive whenever the new rates are based on marginal cost and the older rates are not.

As a result, cost reductions which can be expected to result in similar reductions in the amount of total revenue collected cannot be counted as advantageous effects. Only those costs which are borne by entities other than the water and wastewater utilities, or which are recovered by means other than the charges for water and wastewater service, are eligible to be counted. This is a conservative procedure for advantageous effect estimation, since it ignores the value of increased consumer's surplus which may, in some cases, be substantial. To attempt such a measurement, however, would require detailed econometric analysis of the demand for municipal water in Tucson.

The cost items which affect external advantageous effects for water use reduction due to marginal cost rates are:

1. The portion of the CAP project cost which is not borne by the water utility (estimated as 72 percent of project costs); and

2. Cost foregone by downstream irrigators (offsetting the first term).

These incremental costs are \$107,470/mgd (average day)/year and -\$22,400/mgd (sewer contribution)/year, respectively, both stated for sustained reductions beginning in the base year. The values of these incremental costs for selected years after the base year are shown on Table 85, columns two and three.

Table 85 also shows the cumulative values of the related water use reductions, and the incremental changes between selected years. When multiplied by the proper incremental costs, these values give annual foregone costs attributable to the incremental reductions in average day water use and average day sewer contribution. The negative quantities shown in the table indicate increases rather than reductions in water use.

Measure T3--Subsidized Loans for Landscape Changes

To the extent that landscape changes are implemented as a result of the availability of low-cost loans for this purpose, seasonal water use will be reduced. Since only properties existing in the base year would

TABLE 85

FOREGONE COST CALCULATIONS FOR MEASURE T2

	Supply Cost/Use Reduction (DOLLARS PER MGD)		Effectiveness (MGD)				Annualized Foregone Cost (DOLLARS PER YEAR)	
			Average Day		Sewer Contribution			
Year	Long-Run (Ave Day)	External (Sewer Cont.)	Cumulative	Incremental	Cumulative	Incremental	Long-Run	External
1980	107,470	(22,400)[1]	(0.42)	(0.42)	(2.66)	(2.66)	(45,140)	59,580
1981	92,310	(20,910)	(0.86)	(0.44)	(5.44)	(2.78)	(40,620)	58,130
1982	77,120	(19,510)	(1.14)	(0.28)	(8.41)	(2.97)	(21.580)	57,940
1983	61,920	(18,200)	(1.39)	(0.25)	(8.91)	(0.50)	(15,480)	9,100
1984	46,680	(16,970)	(1.43)	(0.04)	(9.15)	(0.24)	(1,870)	4,070
1985	31,460	(15,830)	(1.47)	(0.04)	(9.39)	(0.24)	(1,250)	3,800
1986	16,220	(14,760)	(1.51)	(0.04)	(9.63)	(0.24)	(650)	3,540
1987	- 0 -	(13,750)	(1.54)	(0.03)	(9.88)	(0.25)	- 0 -	3,440
1990	- 0 -	(11,110)	(1.66)	(0.12)	(10.60)	(0.72)	- 0 -	8,000
2000	- 0 -	(5,310)	(2.02)	(0.36)	(12.84)	(2.24)	- 0 -	11,890
2010	- 0 -	(2,320)	(2.25)	(0.23)	(14.70)	(1.86)	- 0 -	4,320
2020	- 0 -	(790)	(2.61)	(0.36)	(16.73)	(2.03)	- 0 -	1,600
2030	- 0 -	- 0 -	(2.94)	(0.33)	(18.75)	(2.02)	- 0 -	- 0 -
Sub-Total							(126,590)	225,410
Total								98,820

[1] Parentheses indicate negative quantity

be eligible for such loans, the effectiveness would increase during the ten-year implementation period, then remain constant thereafter. The final level of effectiveness, as calculated earlier, is a reduction of 0.48 mgd in average day water use, and of 1.73 mgd in maximum day water use. Sewer contribution is unchanged.

Table 86 shows the annual cost savings during the ten-year implementation period of this measure. The incremental changes in the various dimensions of water use are also shown, and the sum of the products of cost increments and incremental use reductions is given as the annual foregone costs. The sum of annual foregone costs for ten years is the total annualized foregone cost for the water conservation measure.

It can be seen from Table 86 that the annualized foregone cost for the subsidized load program is equal to $186,380/year. The cost of this program was calculated earlier at $1,360,000/year, more than seven times the annual advantageous effect. This conservation measure, therefore, is not economically feasible. Its continued consideration is contingent upon identification of a net advantageous effect with respect to the environmental quality objective.

FOREGONE NED BENEFITS

Since no Federal multi-purpose water supply plan is under consideration for the Tucson region, reduction in water use will not cause NED benefits associated with other purposes to be foregone.

REDUCED NEGATIVE EQ EFFECTS

As noted under measure-specific analysis, advantageous effects are likely to result from any reduction in the withdrawal of groundwater. These advantageous effects appear when the negative EQ effects expected as a result of continued pumping are reduced or delayed. They include the reduced probability of land subsidence in the Tucson metropolitan area and reduced riparian damage in the Avra and Altar valleys. Both effects stem directly from reduced rates of drawdown of the groundwater aquifers. The magnitude of these advantageous effects, although not quantified, may be assumed to increase with increasing effectiveness of water conservation.

INCREASED NEGATIVE EQ EFFECTS

No instances of increased negative EQ effects attributable to water conservation have been identified.

TABLE 86

FOREGONE COST CALCULATIONS FOR MEASURE T3

	Supply Cost/Use Reduction (DOLLARS PER MGD)				Incremental Use Reductions (MGD)			Annualized Foregone Cost (DOLLARS PER YEAR)	
	Short-Run	Long-Run							
Year	(Ave. Day)	(Ave. Day)	(Max. Day)	(Max. Day-Max. Month)	(Ave. Day)	(Max. Day)	(Max. Day-Max. Month)	Short-Run	Long-Run
1980	114,610	216,070	73,700	56,200	- 0 -	- 0 -	- 0 -	- 0 -	- 0 -
1981	106,960	187,630	73,700	52,450	0.048	0.073	0.058	5,130	24,800
1982	99,810	159,150	73,700	48,940	0.048	0.173	0.058	4,790	23,230
1983	93,110	130,660	73,700	45,660	0.048	0.173	0.058	4,470	21,670
1984	86,850	102,120	73,700	42,590	0.048	0.173	0.058	4,170	20,120
1985	80,980	73,590	73,700	39,710	0.048	0.173	0.058	3,890	18,580
1986	75,500	45,050	73,700	37,020	0.048	0.173	0.058	3,620	17,070
1987	70,370	15,140	18,900	34,510	0.048	0.173	0.058	3,380	5,990
1988	65,570	13,250	18,900	32,150	0.048	0.173	0.058	3,150	5,760
1989	61,070	11,360	18,900	29,950	0.048	0.173	0.058	2,930	5,560
1990	56,870	9,470	18,900	27,890	0.048	0.173	0.058	2,730	5,340
Sub-Total								38,260	148,120
Total									186,380

SUMMARY OF EVALUATION

The three water conservation measures studied for Tucson have been reviewed for advantageous and disadvantageous effects, with respect to both the NED and EQ objectives. The effects which have been identified and measured are summarized on Table 87. The combined quantified advantageous NED effects outweigh the combined disadvantageous NED effects for measures T1 and T2; measure T3 shows a deficit on the NED account. All three measures are accompanied by advantageous EQ effects, and measure T2 would also result in an unquantified advantageous NED effect (increased consumer satisfaction). In the case of measure T1, however, possible reduced consumer satisfaction must be set against the advantageous effects. Since combined advantages outweigh combined disadvantages for at least one objective in every case, all three measures are eligible for possible inclusion in a water conservation proposal.

TABLE 87

SUMMARY OF WATER CONSERVATION MEASURES: TUCSON

Measure	Advantageous Effects			Disadvantageous Effects	
	Average Annual Effectiveness (MGD)	NED (DOLLARS PER YEAR)	EQ & Non-Quantified NED	NED (DOLLARS PER YEARS)	EQ & Non-Quantified NED
T1-Plumbing Code Changes	5.77	1,279,900	C, D	- 0 -	B
T2-Change in Price Structure	(2.04)	98,820	A	5,340	F, G
T3-Subsidized Loans for Landscape Change	0.43	186,380	C, D, E	1,360,000	none identified

A - Unquantified increase in consumer satisfaction (increased consumer surplus)
B - Unquantified decrease in consumer satisfaction due to operation of fixtures
C - Reduced probability of land subsidence in Tucson metropolitan area
D - Reduced riparian damage in Avra and Altar valleys
E - Improved appearance of residential areas
F - Increased probability of land subsidence in Tucson metropolitan area
G - Increased riparian damage in Avra and Altar valleys
H - Potentially acceptable; measure must be perceived by public as not adversely affecting growth and economic development

CHAPTER X

INTEGRATION OF WATER CONSERVATION INTO WATER SUPPLY PLANS

ELIGIBLE WATER CONSERVATION MEASURES

The evaluation of three representative water conservation measures for Tucson results in two measures which meet eligibility criteria unconditionally, and another which meets the criteria conditionally. All three measures meet the test of applicability, feasibility, and effectiveness. Two measures are found socially acceptable, but one, requiring a change in the plumbing code, is judged potentially acceptable. This finding reflects the considerable sensitivity noted in Tucson to actions which may adversely affect growth. The specific measure evaluated was designed to avoid such effect, but its social acceptability would depend upon persuading the community of this fact. All three measures provide net advantageous effects with respect to the NED objective, the EQ objective, or both. The eligible measures are listed again on Table 89, which also summarizes the information necessary to place these measures in merit order.

As noted earlier, consideration of alternative Federal water supply plans will, in general, lead to alternative estimates of the effects for individual water conservation measures. For a given measure, each alternative estimate of advantageous and disadvantageous effects is contingent on the implementation of one of the Federal plans under consideration. In order to develop a water conservation proposal for incorporation as an element in one of the Federal plans, the estimates used must be those derived from the water supply element of that plan.

In the case of this illustrative example, no Federal water supply plans were under consideration at the time of data collection. The advantageous effects developed in the previous section derive from the characteristics of local plans and facilities only. In order to illustrate the process of integrating water conservation into a water supply plan, however, this section is written as though two Federal plans existed: a NED plan and an EQ plan. The same set of advantageous effect estimates is used in each case, although in practice separate sets of estimates would be available.

NED PROJECT PLAN

Merit Order

For purposes of preparing the water conservation proposal to be included in the NED project plan, eligible measures are placed in merit order according to net NED advantageous effect. The calculations, and the resulting merit order, are shown in Table 90. Advantageous and disadvantageous effects are stated as annualized values, based on a 6.875 percent discount rate and a 50-year planning period.

TABLE 88

SUMMARY OF NED ADVANTAGEOUS AND DISADVANTAGEOUS EFFECTS OF WATER CONSERVATION MEASURES[1]

	T1--Plumbing Code Changes	T2--Change in Price Structure	T3--Loans for Landscape Change
ADVANTAGES			
a. Unrelated to water use reduction	- 0 -	- 0 -	- 0 -
b. Indirectly related to reduction	595,000	- 0 -,A	- 0 -
c. Foregone supply cost			
i. short-run/federal plan	- 0 -	- 0 -	- 0 -
ii. long-run/federal plan	- 0 -	- 0 -	- 0 -
iii. short-run/non-federal facilities	354,070	- 0 -	38,260
iv. long-run/non-federal facilities	392,020	(126,590)	148,120
v. external opportunity costs	(61,190)	225,410	- 0 -
d. Total NED Advantages	1,279,900	98,820,A	186,380
DISADVANTAGES			
a. Implementation costs	- 0 -	5,350	1,360,000
b. Other disadvantageous effects	- 0 -,B	- 0 -	- 0 -
c. Foregone NED benefits	- 0 -	- 0 -	- 0 -
d. Total NED Disadvantages	- 0 -,B	5,350	1,360,000

[1]Effects shown are for implementation of each measure individually; NED effects are in annualized $/year.
A-Unquantified increase in consumer satisfaction (increased consumer surplus).
B-Unquantified decrease in consumer satisfaction due to operation of fixtures.

TABLE 89

SUMMARY OF EQ ADVANTAGEOUS AND DISADVANTAGEOUS EFFECTS OF WATER CONSERVATION

	T1--Plumbing Code Changes	T2--Change in Price Structure	T3--Loans for Landscape Change[1]
ADVANTAGES			
a. Unrelated or indirectly related to water use reduction	none identified	none identified	C
b. Directly related to water use reduction			
i. Federally planned facilities	n/a	n/a	n/a
ii. non-Federal facilities	A,B	none identified	A,B
c. Total EQ Advantages	A,B	none	A,B,C
DISADVANTAGES			
a. Unrelated or indirectly related to water use reduction	none anticipated	none anticipated	none anticipated
b. Directly related to water use reduction			
i. Federally planned facilities	n/a	n/a	n/a
ii. non-Federal facilities	none anticipated	D,E	none anticipated
c. Total EQ Disadvantages	none	D,E	none

[1] Effects shown are for implementation of each measure individually; NED effects are in annualized $/year

A-Reduced probability of land subsidence in Tucson metropolitan area

B-Reduced riparian damage in Avra and Altar valleys

C-Improved appearance of residential areas

D-Increased probability of land subsidence in Tucson metropolitan area

E-Increased riparian damage in Avra and Altar valleys

TABLE 90

NED MERIT ORDER
(DOLLARS PER YEAR)

Measure	NED Effects Advantageous	NED Effects Disadvantageous	Net NED Advantage
T1	1,279,900	- 0 -	1,279,900
T2	98,820	5,350	93,470
T3	186,380	1,360,000	(1,173,620)

Measures Planned or Implemented

Table 91 indicates the water conservation measures planned or implemented for Tucson. These measures are considered part of the without project conditions.

PROPOSAL DEVELOPMENT

First Trial

The first trial proposal consists of the measure with the largest net NED advantage, measure T1. Its characteristics are the same as those shown for measure T1 on Table 89, and are shown on the first line of Table 92.

Second Trial

The second trial consists of the first proposal, with the next-best measure added: T2. Interactions with respect to effectiveness can be noted for those two measures. Since the marginal cost based pricing plan to be implemented as measure T2 includes summer prices which are substantially higher than any now in effect, it seems likely that increased attention would be given to the use of water saving appliances, with or without a plumbing code change. If sufficient consumer interest were generated, homebuilders would undoubtedly be willing to equip new homes with the water saving features. It would be difficult to estimate the extent of this voluntary change, but it might be assumed, for the sake of illustration, that 10 percent of the effectiveness of measure T1

TABLE 91

WATER CONSERVATION MEASURES PLANNED OR IMPLEMENTED
FOR TUCSON
(1979)

1. Educations Efforts to Reduce Seasonal Water Use. Tucson's "Beat the Peak" program has significantly reduced seasonal water use through a continuing, multi-media educational effort which encourages residential water users to minimize lawn and garden watering, to water at off-peak times, and to replace lawns and gardens with desert vegetation. The city has also re-landscaped some public areas, included boulevard median strips, which were formerly irrigated.

2. Rate Structure Reform. Tucson's water rates are explicitly designed to create incentives to conserve water. They include both increasing block and summer surcharge features.

3. Non-potable Reuse of Treated Wastewater. The treated effluent from a 1 mgd wastewater treatment plant is used to irrigate three golf courses in the Randolph Park area, replacing the former use of city water for this purpose.

4. Leak Detection. The Tucson Water Department maintains an effective leak detection and repair program.

5. Metering. Tucson is fully metered.

TABLE 92

SUMMARY OF TRIAL WATER CONSERVATION PROPOSALS: TUCSON

Water Conservation Proposal	Measures	Average Annual Effectiveness (MGD)	Advantageous Effects: NED (DOLLARS PER YEAR)	Advantageous Effects: EQ and Non-Quantified NED Effects[1]	Disadvantageous Effects: NED (DOLLARS PER YEAR)	Disadvantageous Effects: EQ and Non-Quantified NED Effects[1]	Net NED Advantage (DOLLARS PER YEAR)	
NED Project Proposals								
1.	T1	5.77	1,279,900	C,D	- 0 -	B	1,279,900	H
2.	T1, T2	3.15	1,310,230	A, C, D	5,350	B	1,304,880	H,I[2]
3.	T1, T2, T3	3.58	1,496,610	A,C,D,E	1,365,350	B	131,260	H,I
EQ Project Proposals								
1.	T1	5.77	1,279,900	C,D	- 0 -	B	1,279,900	H
2.	T1, T3	6.20	1,466,280	C, D, E	1,360,000	B	106,280	H[2]
3.	T1, T3, T2	3.58	1,496,610	A,C,D,E	1,365,350	B	131,260	H,I

[1]Notes:
- A - Unquantified increase in consumer satisfaction (increased consumer surplus) (measure T2)
- B - Unquantified decrease in consumer satisfaction due to operation of fixtures (measure T1)
- C - Reduced probability of land subsidence in Tucson metropolitan area (measures T1 and T3)
- D - Reduced riparian damage in Avra and Altar valleys (measure T3)
- E - Improved appearance of residential areas (measure T3)
- H - Potentially acceptable; measure must be perceived by public as not adversely affecting growth and economic development
- I - Measure T2 increases average annual water use (nagative effectiveness)

[2]Final Proposal

would consist of response which measure T2 alone would have produced.

The total effectiveness, therefore, would be that of measure T2 plus 90 percent of the listed effectiveness of measure T1. Advantageous effects directly related to water use (see Table 88) can be adjusted accordingly. The other advantageous effect obtained from energy savings would remain the same. Implementation costs are unchanged by joint implementation. The characteristics of this proposal are summarized on Table 92.

Third Trial

The third trial consists of the second proposal, with the next-best measure added. The remaining measure, T3, exhibits no significant interaction with the measures already in the proposal. (Since adoption of T3 is not cost-effective, higher prices are not assumed to affect effectiveness appreciably.) Trial Proposal 3 can be seen to add a negative increment to the NED objective, compared to Proposal 2. Trial Proposal 2, therefore, is the final proposal, suitable for inclusion in the NED project plan.

EQ PROJECT PLAN

Merit Order

For purposes of preparing the water conservation proposal for inclusion in the EQ project plan, eligible measures are placed in merit order according to net contribution to the environmental quality objective. For two of the measures analyzed for Tucson (T1 and T3), only beneficial EQ effects appear. All reductions in groundwater pumping reduce the probability of future land subsidence in the Tucson area, and they may reduce possible further damage to vegetation in the Avra and other basins, due to falling groundwater tables. The greater the effectiveness of the measure in reducing water use, the greater the beneficial environmental effect. Following this logic, measure T2, which increases total annual water use, may be presumed to have a negative environmental effect. The appropriate merit order, therefore, is shown as Table 93.

PROPOSAL DEVELOPMENT

First Trial

The first trial proposal consists of the measure ranked first in merit order, measure T2. Its characteristics, shown on Table 88, are repeated on Table 92.

Second Trial

The second trial proposal consists of the first proposal with the

TABLE 93

EQ MERIT ORDER
(DOLLARS PER YEAR)

Measure	Environmental Effects	Net NED Advantage
T1	Reduced probability of future land subsidence; possible reduced environmental damage in Avra and Altar Valleys (average effectiveness = 5.77 mgd)	1,279,900
T3	Reduced probability of future land subsidence, possible reduced environmental damage in Avra and Altar valleys; possible improved appearance of residential neighborhoods (average effectiveness = 0.43 mgd)	(1,173,620)
T2	Increased probability of future land subsidence; possible increased environmental damage in Avra and Altar valleys (average effectiveness = 2.04 mgd increase in annual water use)	93,470

next-best measure added: measure T3. Since measure T3 addressed water uses which are entirely different from those affected by measure T1, there is no evident interaction between the two measures. The characteristics of the second trial proposal, shown on Table 92, are the sums of the characteristics of measures T1 and T3, as shown on Table 88.

Third Trial

The third trial proposal consists of the second proposal, with the next-best measure added: measure T2. As noted above, measure T2 interacts with measure T2 with respect to effectiveness and advantageous NED effects. The same assumptions are made here: The combined effectiveness is equal to the sum of the effectiveness of T2, T3, and 90 percent of T1. Measure T2, however, can be seen to decrease the overall contribution to the EQ objective. Since the purpose of this proposal is to maximize that contribution, Trial Proposal 3 is rejected and the second trial is the final proposal.

ALTERNATE PROPOSALS

Since measure T1 is potentially socially acceptable, consideration must be given to water conservation proposals which exclude this measure. In more complex applications, these alternate proposals would be developed by the same process outlined above, utilizing appropriate merit orderings and yielding results comparable to those on Table 93. In the present case, however, only two measures remain after excluding measure T1, and these measures do not interact.

The alternate conservation proposal which maximizes net NED advantage, therefore, consists of measure T2 alone. Its characteristics are those of measure T2. The alternate water conservation proposal which maximizes advantageous effects on the EQ objective is identical, for the same reasons, to measure T3. Its characteristics are those of measure T3. These results are shown on Table 94.

Comparisons of the water conservation plans developed with measure T1 to the corresponding plans developed without T1 indicate that a substantial incentive exists for the implementation of this measure. The net benefit obtained from the NED proposal is reduced $1,211,410/year by its exclusion; the net contribution to the EQ objective obtained from the EQ proposal is reduced by more than 90 percent. These comparisons suggest that the effort required to secure acceptance for plumbing code changes is well justified.

DOCUMENTATION OF SELECTED PROPOSALS

Applicable Water Conservation Measures

The water conservation measures found applicable in the Tucson area are listed by general category on Table 75. These applicable measures which were subjected to further analysis in this study appear on Table 95, together with an indication of technical feasibility, social acceptability, eligibility, and subsequent integration into water supply plans.

Measures Already Implemented

Water conservation measures already implemented, or scheduled for implementation in Tucson are shown on Table 91.

Federal Water Supply Plans

As discussed earlier, no Federal water supply plan exists for the Tucson area at the time of this study. In order to illustrate the process of formulating water conservation proposals and integrating those proposals into water supply plans, however, this section has been prepared as though Federal plans existed. Two Federal water supply plans are assumed: a NED plan and EQ plan. Since all advantageous and disadvantageous effects for water conservation measures were based on

TABLE 94

SUMMARY OF ALTERNATE WATER CONSERVATION PROPOSALS: TUCSON

Water Conservation Proposal	Measures	Average Annual Effectiveness (MGD)	Advantageous Effects: NED (DOLLARS PER YEAR)	Advantageous Effects: EQ and Non-Quantified NED Effects[1]	Disadvantageous Effects: NED (DOLLARS PER YEAR)	Disadvantageous Effects: EQ and Non-Quantified NED Effects[1]	Net NED Advantage (DOLLARS PER YEAR)	
NED Project Proposals								
1.	T2	(2.04)	98,820	A	5,350	F, G	93,470	I[2]
2.	T2, T3	(1.61)	186,380	A, E	1,365,350	F, G	(1,080,150)	I
EQ Project Proposals								
1.	T3	0.43	168,380	C,D,E	1,360,000	none identified	(1,173,620)	2
2.	T3, T2	(1.61)	285,200	A, E	1,365,350	F, G	(1,080,150)	I

[1]Notes:
A - Unquantified a increase in consumer satisfaction (increased consumer surplus) (measure T2)
C - Reduced probability of land subsidence in Tucson metropolitan area (measures T1 and T3)
D - Reduced riparian damage in Avra and Altar valleys (measure T3)
E - Improved appearance of residential areas (measure T3)
F - Increased probability of land subsidence in Tucson metropolitan area (measure T2)
G - Increased riparian damage in Avra and Altar valleys (measure T2)
I - Measure T2 increases average annual water use (negative effectiveness)

[2]Final Proposal

TABLE 95

SUMMARY OF APPLICABLE WATER CONSERVATION MEASURES: TUCSON

Measure	Technical Feasibility	Social Acceptability	Net Impact		Eligible	Plan Inclusion	
			NED Objective	EQ Objective		NED Plan	EQ Plan
T1--Plumbing Code Changes	Feasible	Potentially Acceptable	Positive	Positive	yes	yes	yes
T2--Change in Price Structure	Feasible	Acceptable	Positive	Negative	yes	yes	no
T3--Loans for Landscape Changes	Feasible	Acceptable	Negative	Positive	yes	no	yes

non-Federally planned facilities, these effects do not differ between the plans, as would be expected. Also, in summarizing the effects of the proposals, the columns provided for foregone Federal project cost are blank. No descriptions of the Federal plan with or without the conservation element are provided, as required by the procedure.

NED Project Plan

The water conservation plan which is to be integrated into the NED water supply plan consists of measures T1 and T2. The proposal is described on Tables 96 through 100.

TABLE 96

TUCSON NED WATER CONSERVATION PROPOSAL: MEASURES

Description of Measures

T1--Plumbing Code Change: Plumbing codes would be changed to require that all new or substantially remodeled structures utilize water closets which use no more than 3.5 gallons per flush, and shower heads which permit no more than 3.5 gallons per minute flow. Code changes would be effective immediately.

T2--Change in Price Structure: A marginal cost of service study would be performed for the Tucson water and wastewater utilities, and used as the basis of a new, integrated water/wastewater rate structure which sets charges equal to the relevant marginal costs. The new rate structure would be implemented in the base year, and adjusted as cost conditions and revenue requirements warrant thereafter.

Implementation Details

The plumbing code change would require action by the Tucson City Council, including public hearings and an opportunity for all affected parties to comment. Once the code had been changed, enforcement effort would be identical to that required for existing plumbing and building codes. No significant implementation. Costs would be indicated.

Price structures for water and wastewater services are recommended by the Department of Water and Sewers and approved by the City Council. The marginal cost of service study would be undertaken by the Department of Water and Sewers, or its consultant, and the proposed rates developed as part of that study. Subsequent rate changes would be comparable to those required by current rate-making policy.

TABLE 97

TUCSON NED WATER CONSERVATION PROPOSAL: IMPLEMENTATION COSTS

Measure	Cost (Annualized $/Year)
T1	- 0 -
T2	$ 5,350
Total	$ 5,350

TABLE 98

TUCSON NED WATER CONSERVATION PROPOSAL: EFFECTIVENESS

Measure	Water Use Reduction (MGD)					
	1980	1990	2000	2010	2020	2030
Maximum Day Water Use						
T1	0.0	2.16	4.41	6.30	8.10	9.99
T2	3.26	13.10	15.88	18.38	20.72	23.17
Totals	3.26	15.26	20.29	24.68	28.82	33.16
Average Day Water Use						
T1	0.0	2.16	4.41	6.30	8.10	9.99
T2	(0.42)[1]	(1.66)	(2.02)	(2.25)	(2.61)	(2.94)
Totals	(0.42)	0.50	2.39	4.05	5.49	7.05
Average Day Sewer Contribution						
T1	0.0	2.16	4.41	6.30	8.10	9.99
T2	(2.66)	(10.60)	(12.84)	(14.70)	(16.73)	(18.75)
Totals	(2.66)	(8.44)	(8.43)	(8.40)	(8.63)	(8.76)
Maximum Day less Average Day of Maximum Month						
T1	0.0	0.0	0.0	0.0	0.0	0.0
T2	1.09	4.37	5.29	6.13	6.91	7.72
Totals	1.09	4.37	5.29	6.13	6.91	7.72

[1]Parentheses indicate negative value

TABLE 99

TUCSON NED WATER CONSERVATION PROPOSAL: NED OBJECTIVE

Changes in Beneficial Effects (Annualized $/Year)

Measure	Foregone Non-Federal Supply Cost[1,2]	Other Advantageous Effects[3]	Net Increase in Beneficial Effects
T1	616,410	595,000	1,211,400
T2	98,820	- 0 -	98,820
Totals	715,230	595,000	1,310,230

Changes in Adverse Effects (annualized $/year)

Measure	Implementation Costs	Other Dis-advantageous Effects[3]	Less: Foregone Federal Supply Costs[4]	Net Increase In Adverse Effects
T1	- 0 -	- 0 -	- 0 -	- 0 -
T2	5,350	- 0 -	- 0 -	5,350
Totals	5,350	- 0 -	- 0 -	5,350

[1] Existing and locally planned facilities, foregone supply cost
[2] Includes foregone external opportunity costs
[3] Unrelated and indirectly related to water use reduction
[4] Federally planned facilities, foregone supply cost

TABLE 100

TUCSON NED WATER CONSERVATION PROPOSAL: EQ OBJECTIVE

Changes in Beneficial Effects

Measure	Reduction in Non-Federal Negative EQ Effects[1]	Other Advantageous Effects[2]	Net Increase in Beneficial Effects
T1	(reduced probability of land subsidence and riparian damage due to aquifer drawndown)	none	positive
T2	(increased probability..)	none	negative

Changes in Adverse Effects

Measures	Increase in Negative EQ Effects: Federal[2]	Non-Federal[1]	Other Disadvantageous Effects[2]	Less Reduction in Federal Negative EQ Effects[3]	Net Increase in Adverse Effects
T1	none	none	none	none	none
T2	none	none	none	none	none

[1] Existing and locally planned facilities, foregone supply cost
[2] Unrelated and indirectly related to water use reduction
[3] Federally planned facilities, foregone supply cost

EQ Project Plan

The water conservation proposal which is to be integrated into the EQ water supply plan consists of measure T1 and T3. The proposal is described on Tables 101 through 105.

TABLE 101

TUCSON EQ WATER CONSERVATION PROPOSAL: MEASURES

Description of Measures

T1--Plumbing Code Change: Plumbing codes would be changed to require that all new or substantially remodeled structures utilize water closets which use no more than 3.5 gpm flow. Code changes would be effective immediately.

T3--Subsidized Loans for Landscape Changes: The City of Tucson would initiate a program of low-cost loans to persons who wish to change existing lawns and gardens to desert vegetation. Interest rates would be set high enough to recover the City's cost of tax-exempt bond funds, plus administrative costs. Loans would be available to owners of existing homes which have previously been landscaped with humid climate vegetation. The program would be in effect during the first ten years of the planning period.

Implementation Details

The plumbing code change would require action by the Tucson City Council, including public hearings and an opportunity for affected parties to comment. Once the code has been changed, enforcement effort would be identical to that required for existing plumbing and building codes. No significant implementation cost would be indicated.

Low-cost loans for landscape changes would be available to eligible homeowners on application to the appropriate city agency. Homeowners would bear a cost equal to the full cost of the landscape change, financed at a subsidized rate or interest. The difference between commercial interest rates and the subsidized rate is cost borne by the nation as a whole (due to lower federal income tax revenues). The full NED implementation cost, therefore, is equal to the cost of the landscape changes as financed at commercial rates, plus any administration costs incurred by the City. Since there is no positive economic incentive to make such changes, it is estimated that this program will be responsible for only 300 conversions per year for ten years.

TABLE 102

TUCSON EQ WATER CONSERVATION PROPOSAL:
IMPLEMENTATION COSTS

Measure	Cost (Annualized Dollars Per Year)
T1	- 0 -
T2	$ 1,360.000
Total	$ 1,360,000

TABLE 103

TUCSON EQ WATER CONSERVATION PROPOSAL: EFFECTIVENESS

Measure	Water Use Reduction (MGD)					
	1980	1990	2000	2010	2020	2030
Maximum Day Water Use						
T1	0.0	2.40	4.90	7.00	9.00	11.10
T3	0.0	1.73	1.73	1.73	1.73	1.73
Totals	0.0	4.13	6.63	8.73	10.73	12.83
Average Day Water Use						
T1	0.0	2.40	4.90	7.00	9.00	11.10
T3	0.0	0.48	0.48	0.48	0.48	0.48
Totals	0.0	2.88	5.38	7.48	9.48	11.58
Average Day Sewer Contribution						
T1	0.0	2.40	4.90	7.00	9.00	11.10
T3	0.0	0.0	0.0	0.0	0.0	0.0
Totals	0.0	2.40	4.90	7.00	9.00	11.10
Maximum Day Less Average Day of Maximum Month						
T1	0.0	0.0	0.0	0.0	0.0	0.0
T3	0.0	0.58	0.58	0.58	0.58	0.58
Totals	0.0	0.58	0.58	0.58	0.58	0.58

TABLE 104

TUCSON EQ WATER CONSERVATION PROPOSAL: EQ OBJECTIVE

Changes in Beneficial Effects

Measure	Reduction in Negative EQ Effects[1]	Other Disadvantageous Effects[2]	Net Increase In Beneficial Effects
T1	(reduced probability of land subsidence and riparian damage due to aquifer drawdown)	none	positive
T3	(increased probability...)	(improved appearance of residential areas)	negative

Changes in Adverse Effects

Measure	Increase in Negative EQ Effects: Federal[2]	Increase in Negative EQ Effects: Non-Federal[1]	Other Disadvantageous Effects[2]	Less Reduction in Federal Negative EQ Effects[3]	Net Increase in Adverse Effects
T1	none	none	none	none	none
T3	none	none	none	none	none

[1] Existing and locally planned facilities, foregone supply cost
[2] Unrelated and indirectly related to water use reduction
[3] Federally planned facilities, foregone supply cost

TABLE 105

TUCSON EQ WATER CONSERVATION PROPOSAL: NED OBJECTIVE

Changes in Beneficial Effects

Measure	Foregone Non-Federal Supply Cost[1,2]	Other Advantageous Effects[3]	Net Increase in Beneficial Effects
T1	684,900	595,000	1,279,900
T3	186,380	- 0 -	186,380
Totals	871,280	595,000	1,466,280

Changes in Adverse Effects

Measure	Implementation Costs	Other Dis-advantageous Effects[3]	Less: Foregone Federal Supply Costs[4]	Net Increase In Adverse Effects
T1	- 0 -	- 0 -	- 0 -	- 0 -
T3	1,360,000	- 0 -	- 0 -	1,360,000
Totals	1,360,000	- 0 -	- 0 -	1,360,000

[1] Existing and locally planned facilities, foregone supply cost
[2] Includes foregone external opportunity costs
[3] Unrelated and indirectly related to water use reduction
[4] Federally planned facilities, foregone supply cost

Alternative Water Conservation Proposals

If the water conservation proposals described on Tables 96 through 105 could not be implemented because measure T1 was found to be socially unacceptable, alternate proposals would consist of the single water conservation measures T2 and T3, respectively. The characteristics of these measures are described in the text, and are not repeated here.

Performance of Water Supply/Conservation Plans under Drought Conditions

Since no federal water supply plans were under consideration for Tucson at the time of this study, no examination was made of the performance of these plans under drought conditions. Table 106 indicates the information which such a study would be expected to yield.

TABLE 106

PERFORMANCE UNDER DROUGHT CONDITIONS[1]
(MGD)

Project Plan	Maximum Day Supply Capability	Maximum Day Water Use Without Emergency Measures	Effectiveness of Emergency Measures	Deficit
NED Project Plan				
Without conservation	--	--	--	--
With conservation	--	--	--	--
EQ Project Plan				
Without conservation	--	--	--	--
With conservation	--	--	--	--

[1]All data are for year 2030, under design drought supply and demand conditions.

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APPENDIX A

INTERVIEW GUIDES

APPENDIX A

INTERVIEW GUIDE: ATLANTA

I. I'd like to review with you a number of possible water conservation measures by asking you three questions about each of them.

Conservation Measures

A. Conservation through pricing (increasing block rates); that is, the cost per gallon increases as the amount of water used increases. (Probe for residential and industrial uses.)

B. Conservation through building or plumbing codes; that is, mandatory use of water-saving plumbing appliances, such as low-flow toilets and shower heads, in new construction and replacement.

C. Reduction of outside lawn and garden watering via restriction to certain hours.

D. Increased use of renovated wastewater (treated sewage) for industry and agriculture (irrigation).

E. Educational efforts aimed at developing or changing water use habits, such as, turning off tap during brushing of teeth, washing only full-loads, using shower only to wet and rinse, etc.

F. Controlling or limiting urban growth and development, for instance, by issuing limited numbers of building permits, or not increasing water facilities.

Questions

1. How well do you think it would work; that is, would it, indeed conserve a significant amount of water?

2. How economical do you think it would be; that is, would it be worth it?

3. Who would be for it and who against it? Why? (Probe various publics, levels of government, business, industry, labor, special interest groups, politicians, etc.)

II. The growth question is such an important one, let's go into it a bit more:

A. What do you see as the positive aspects of the growth and development of the Atlanta metropolitan area?

B. And the negative?

C. Here's a quote from the study on water management done a few years back:

> Inherent in the planning process is the knowledge that technically feasible alternatives may not be desirable due to institutional, economic, legal, or other reasons. It was not the purpose of the water supply investigations to address the continuing question of whether the projected growth should be allowed to occur. It will be the responsibility of state and local governments, with public guidance, to decide if the various impacts of technical alternatives are warranted to accommodate the projected growth.

What's your response to that position? Who indeed should decide whether or not growth shall take place? It is a controllable phenomenon?

D. There has been some disagreement regarding the extent of the projected growth for Greater Atlanta; what is the current picture of anticipated growth?

III. Given a political/social mandate to either encourage, accommodate, or inhibit growth, what parties should be involved in making the appropriate water management decisions that would follow? (Probe professionals, publics.)

IV. Are there current or potential points of conflict regarding water conservation measures between various governmental levels (federal, state, county, municipality), or between various agencies within the same level?

V. I'd like to end with a question which, while perhaps not directly related to water conservation, is important for understanding the issues involved in water management policies in general in the Greater Atlanta area. Let me use another quote from the water management study:

> [Studies]...continued for developing a long-range water management plan to meet the needs of the region beyond the year 2000, and that specific consideration be given to plans for (1) constructing a reregulation facility downstream from Buford Dam, (2) further raising the level of Lake Lanier, (3) increasing storage capacity of Georgia Power's Morgan Falls Reservoir, (4) providing additional offpeak releases from Buford Dam at expense of hydroelectric power...

What's your preference? Why?

INTERVIEW GUIDE: TUCSON

I. I'd like to review with you a number of possible water conservation measures by asking you three questions about each of them.

Conservation Measures

A. Conservation through pricing (increasing block rates); that is, the cost per gallon increases as the amount of water used increases.

B. Conservation through building or plumbing codes; that is, mandatory use of water-saving plumbing appliances, such as low-flow toilets and shower heads, in new construction and replacement.

C. Reduction of outside lawn and garden watering via restriction to certain hours.

D. Desert landscaping.

E. Increased use of renovated wastewater (treated sewage) for industry and agriculture (irrigation).

F. Educational efforts at conservation, such as voluntary installation of water-saving appliances, development of in-house habits (turning off tap during brushing of teeth, washing only full-loads, etc.).

G. Controlling or limiting urban growth and development, for instance, by limiting building permits, or zoning, or not building water facilities.

H. Conservation through restricting agriculture in the Tucson area from growing crops that require large amounts of water and permitting only low water crops to be grown.

Questions

1. How well do you think it would work; that is, would it indeed conserve a significant amount of water?

2. How economical do you think it would be; that is, would it be worth it?

3. Who would be for it and who against it? Why? (Probe various publics, levels of government, business, industry, labor, special interest groups, politicians, etc.)

II. The growth question is such an important one, let's go into it a bit more:

   A. What do you see as the positive aspects of the growth and development of the Tucson area?

   B. And the negative?

   C. Whose responsibility is it to decide whether or not an increase in population in the Tucson area shall take place? Is growth a controllable phenomenon?

III. Given a political/social mandate to either encourage, accommodate, or inhibit growth, what parties should be involved in making the appropriate water management decisions that would follow? (Probe professionals, publics.)

IV. Are there current or potential points of conflict regarding water conservation measures between various governmental levels (Federal, state, county, municipality), or between various agencies within the same level?

V. There are two other issues which, while not directly related to water conservation, are important for understanding the water management policies in general in the greater Tucson area. I'd like to get your thinking on them.

   A. The Papago Indian law suit.

   B. The Central Arizona Project.

APPENDIX B

SURVEY QUESTIONNAIRES

INSTRUCTIONS: Down the left side of the paper, several ways of conserving water are described. Please tell us your reactions to each of them by answering the 5 questions asked across the top of the page. For example, read the description of Conservation Measure A, and then answer all 5 questions about it by checking that one of the 4 spaces under each question that best expresses your opinion. When finished, please fill out the background information and then return the questionnaire to us in the enclosed postage-paid envelope. We are most grateful for your cooperation.

	Question 1: How much do you know about this particular water conservation measure?				Question 2: How well do you think it would work?				Question 3: How economical do you think it would be?				Question 4: How serious would the need for water conservation have to be before you think this measure should be adopted?				Question 5: Over-all, how do you evaluate this conservation measure?			
	know nothing	know just a little	know a fair amount	know quite a bit	wouldn't save any water	would save only a very little water	would save a fair amount of water	would save a lot of water	it would cost more than it would be worth	probably come out even, it would cost as much as it would save	it would result in saving some money	it would result in big savings	not at all serious	slightly serious	moderately serious	very serious	it is totally unacceptable to me	not too good, I don't approve	pretty good, I approve	excellent, I enthusiastically approve
CONSERVATION MEASURES																				
A. Individuals install new water-conserving plumbing fixtures such as low-flow toilets and shower heads in their homes.																				
B. City and state governments engage in active campaigns to educate the public on how to conserve water.																				
C. Sewage is processed and the treated water reused for manufacturing and irrigation of crops.																				
D. Building codes require the installation in new buildings of water-conserving plumbing fixtures such as low-flow shower heads and toilets.																				
E. As the amount of water used increases, the price per gallon is raised.																				
F. The city controls the rate of urban growth and thus the demand for water by issuing only a limited number of building permits each year.																				
G. The use of water for lawns and gardens is reduced by half.																				
H. During a severe drought, the government imposes restrictions on water use that if violated result in stiff fines																				
I. Farmers in the region grow only those crops which require relatively little water; crops demanding large amounts of irrigation are not grown.																				
J. The landscaping of new homes uses only those plants that are adapted to the aridity of the region and require little water.																				

To be effective, some of the measures described above would have to be made into law and enforced by government. Generally, how would you feel about this? (Please check one)

I would be strongly opposed	I would be somewhat opposed	I would be somewhat in favor	I would be strongly in favor
___	___	___	___

BACKGROUND INFORMATION

Age: ____ Sex: ____ Occupation: ____________

Education:
- Less than High School graduate ____
- High School graduate ____
- Some College ____
- College graduate ____
- Some graduate work ____
- Masters level degree ____
- Some doctoral work ____
- Doctorate ____

INSTRUCTIONS: Down the left side of the paper, several ways of conserving water are described. Please tell us your reactions to each of them by answering the 5 questions asked across the top of the page. For example, read the description of Conservation Measure A, and then answer all 5 questions about it by checking that one of the 4 spaces under each question that best expresses your opinion. When finished, please fill out the background information and then return the questionnaire to us in the enclosed postage-paid envelope. We are most grateful for your cooperation.

	Question 1 How much do you know about this particular water conservation measure?				Question 2 How well do you think it would work?				Question 3 How economical do you think it would be?				Question 4 How serious would the need for water conservation have to be before you think this measure should be adopted?				Question 5 Over-all, how do you evaluate this conservation measure?			
	know nothing	know just a little	know a fair amount	know quite a bit	wouldn't save any water	would save only a very little water	would save a fair amount of water	would save a lot of water	It would cost more than it would be worth	probably come out even, it would cost as much as it would save	It would result in saving some money	It would result in big savings	not at all serious	slightly serious	moderately serious	very serious	it is totally unacceptable to me	not too good, I don't approve	pretty good, I approve	excellent, I enthusiastically approve
CONSERVATION MEASURES																				
A. Individuals install new water-conserving plumbing fixtures such as low-flow toilets and shower heads in their homes.																				
B. City and state governments engage in active campaigns to educate the public on how to conserve water.																				
C. Sewage is processed and the treated water reused for manufacturing and irrigation of crops.																				
D. Building codes require the installation in new buildings of water-conserving plumbing fixtures such as low-flow shower heads and toilets.																				
E. As the amount of water used increases, the price per gallon is raised.																				
F. The city controls the rate of urban growth and thus the demand for water by issuing only a limited number of building permits each year.																				
G. The use of water for lawns and gardens is reduced by half.																				
H. During a severe drought, the government imposes restrictions on water use that if violated result in stiff fines.																				

To be effective, some of the measures described above would have to be made into law and enforced by government. Generally, how would you feel about this? (Please check one)

I would be strongly opposed	I would be somewhat opposed	I would be somewhat in favor	I would be strongly in favor
___	___	___	___

BACKGROUND INFORMATION

Age: _____ Sex: _____ Occupation: ____________________

Education:
- Less than High School graduate ____
- High School graduate ____
- Some College ____
- College graduate ____
- Some graduate work ____
- Masters level degree ____
- Some doctoral work ____
- Doctorate ____

APPENDIX C

LETTERS AND APPOINTMENT CALENDAR

FIGURE C-1

LETTER OF STUDY INITIATION AND REQUEST FOR ASSISTANCE

July 25, 1979

John Doe
Suite 707
1776 Papago
Tucson, Arizona

Dear Mr. Doe:

Under contract to the U.S. Army Corps of Engineers, we are conducting a study to evaluate the role of conservation in urban water supply and management. To this end we wish to hold discussions with a number of persons whose knowledge and involvements are relevant to this issue. In preliminary planning sessions with the Tucson Urban Study Program of the Corps, you were identified as someone who would make a significant contribution.

We are planning to be in Tucson the week of Monday, August 20, through Friday, August 24, and hope very much that you will be able to schedule, at your convenience, an hour to meet with us. If amenable, it would greatly facilitate our planning if you would set up a tentative appointment on the enclosed form and return it to us. Upon our arrival in Tucson we will call to confirm the appointment. We will be staying at the Marriot (phone: 634-4475) in case you need to get in touch with us.

The recent federal emphasis on water conservation is leading to a reconsideration of local policies; it is important that such reassessments be informed. Once again, we hope you will be able to share your ideas with us.

Sincerely,

John H. Sims, Ph.D.

P.S. If you have any questions, please call Linda Dietrich, Corps of Engineers, Tucson (phone: 792-6796).

FIGURE C-2
INTERVIEW APPOINTMENT SCHEDULE

AUGUST 6	AUGUST 7	AUGUST 8	AUGUST 9	AUGUST 10
Monday	Tuesday	Wednesday	Thursday	Friday
morning Time:_____ Place:_____ __________	morning Time:_____ Place:_____ __________	morning Time:_____ Place:_____ __________	morning Time:_____ Place:_____ __________	morning Time:_____ Place:_____ __________
afternoon Time:_____ Place:_____ __________	afternoon Time:_____ Place:_____ __________	afternoon Time:_____ Place:_____ __________	afternoon Time:_____ Place:_____ __________	afternoon Time:_____ Place:_____ __________
evening Time:_____ Place:_____ __________	evening Time:_____ Place:_____ __________	evening Time:_____ Place:_____ __________	evening Time:_____ Place:_____ __________	evening Time:_____ Place:_____ __________

FIGURE C-3

LETTER OF APPRECIATION

August 15, 1979

Mr. John Doe
Suite 707
1776 Peachtree
Atlanta, Georgia

Dear Mr. Doe:

I want to thank you for participating in our study of the possibilities and consequences of water conservation in Greater Atlanta. Your discussion made a valuable contribution to our understanding of the issues, and your time and consideration are appreciated.

Sincerely,

John H. Sims, Ph.D.

APPENDIX D

CONTRACTOR REPORT ON SOCIAL ACCEPTABILITY OF WATER CONSERVATION MEASURES IN ATLANTA

SOCIAL ACCEPTABILITY

It would appear obvious that the ultimate purpose of a study on the social acceptability of water conservation measures is, by definition, the determination of whether certain measures are or are not socially acceptable, that is, acceptable to the community in which they are proposed. But unlike the determination of technical or even economic feasibility, such clearcut decisions are rarely (if ever) attainable in the area of community acceptance. Both the number and complexity of factors involved preclude the prediction of community response with certainty. The goal, then, of such efforts is a more modest one: to increase the quality of the judgments made as to the probable response a community will make to a proposed measure.

Community response to a conservation measure is, in important part, a function of its congruence with the community's dominant social ideologies. The question is: Is a specific measure perceived as being harmonious with those core values, beliefs, attitudes, and feelings that define a community's commitments, or is it seen as in some way violating them? In so far as progress is made in answering that question, one's judgment as to the social acceptability of the measure improves.

It is clear, then, that to serve the ultimate purpose of making such judgments, it is necessary first to achieve some understanding of those ideological themes in a community that are of relevance to conservation. Thus, the immediate goal of a study to determine the social acceptability of conservation measures is the identification and delineation of those community values, beliefs, attitudes, and feelings that will influence its response to any and all measures.

The studies of social acceptability reported here used interviews with persons perceived by citizen advisors as exercising considerable influence in the community, and mail questionnaires with a representative sample of the general public. In both cases several kinds of issues were discussed. The relevance of obtaining the evaluations of respondents to specific conservation measures that might be proposed in the future is self-evident. But what might be less immediately understood is the rationale for raising matters in these discussions that, at best, may be seen as only tangentially related to water conservation, and, at worst, would appear to be totally unrelated. Examples of such issues are water rights, alternatives for increasing water supply, or the question of inhibiting or fostering urban growth.

Indeed, such issues do not constitute conservation measures. The discussion of them, is, rather, a means to an end. For it is by way of their consideration of such issues, often somewhat controversial, that respondents reveal those values, beliefs, attitudes, and feelings that characterize their social ideologies. Thus, although the restriction of urban growth may not be a possible conservation measure (and certainly not one on which the Corps would take a position), discussion of it may well produce the clearest picture of those values and principles of judgment that the community uses in its evaluation of any and all conservation measures. In other words, discussion of such issues is

often, indeed usually, more successful in leading to the identification and delineation of basic values that is the discussion of specific and circumscribed conservation measures.

It must be re-emphasized that the immediate goal of a study on the social acceptability of conservation measures is to understand the community, to put your finger on its pulse, to get a feel for the various forces at work with it, to know who holds what values and why. For it is only such an understanding-in-depth that can serve as an enduring base for judging community response to any specific measure.

One last point should be made before proceeding to the Atlanta data. The interviews were conducted so as to provide the respondent with a forum in which to present his ideas and feelings as freely and openly as possible. The analysis seeks to preserve the resultant unrestrained and often emotional quality of the respondent's position, for in understanding social ideologies, the strength and quality of the affect that is associated with a position is as important as the substantive aspect of the position itself. It need hardly be added that the views expressed in the data, as well as the passions with which they are held, are totally disassociated from the Corps itself.

Personal Interview Analysis

Although not rigidly fixed, the interview usually followed the pattern given in the Interview Guide. It began with questionning the effectiveness, the economics, and the social acceptability of a half-dozen or so water conservation measures. It then focused on that single conservation issue which prior inquiry had identified as probably most important for Atlanta--a continued high rate of metropolitan growth. The interview then shifted to the who's and how's of effecting conservation, and ended with a discussion of the controversy surrounding the alternatives for augmenting the future water supply of the area.

As anticipated, urban growth was the topic of discussion that yielded the most important insights into the basic values held by various Atlanta interest groups. The issue of growth pervades the interviews regardless of respondent--business, industry, politicians, citizens groups, ethnic representatives, all feel strongly about urban growth, and those commitments and the attendant values they reveal provide the ideological base which in turn influences the specifics of judgment on any conservation effort. Given its primary importance, it will be discussed first.

Growth: The first division in attitudes toward urban growth is between the view of it as determined by unidentified "natural" forces beyond the kin of man, and the view of it as determined by forces set loose, albeit often inadvertantly, by man itself. Respondents holding to the first of these perspectives talk almost reverently about growth as an awesome and mysterious phenomenon:

> It's the nature of the beast, the only thing to stop it is a natural constraint--like if it comes up against no more water.

> Growth is inevitable until it hits a naturally limiting force. Growth can't go beyond the resource base. Ecologists speak of 'carrying factors,' and water may be one of those in the Atlanta region.

More sophisticated respondents who share what is essentially the same belief, discuss growth as an inevitable process determined by impersonal economic forces:

> Growth cannot be artificially limited; it will stop only when the industrial development and population growth reach the state where the quality of life declines--then so will the rate of growth. It is the growth market place.

For such respondents, the metaphors appropriate to urban growth are those of nature--it is <u>tidal</u>. Man himself is seen as being powerless to stop it, only another natural force can do so. The most telling description of how growth ends is one respondent's reference to the "suicidal migration of lemmings into the sea when their population reaches a certain level."

This definition of growth as determined by essentially incomprehensible and uncontrollable forces--having a life cycle of birth and maturity and death of its own, is not peculiar to any one group of respondents; it makes its appearance in business and government and among the environmentalists.

Other respondents (indeed, the majority) drawn from the same groups see growth in an opposite manner, as a phenomenon which man has determined, and which, logically, he could undo. Yet, paradoxically, they too see growth as inevitable. They are, however, decisively divided as to the reasons why. One group appeals to what they see as the American way of life:

> Any attempt to control growth could go against our history since the beginning of allowing people to go where they want to, where the jobs and opportunities are, or a good climate.
>
> Limiting growth isn't the American way--it wouldn't fit into our values.
>
> Most people see growth as a God-given right and any limits placed on this right are seen as damn government interference.
>
> The price of limiting growth would be too high; it could only be achieved through dictatorial steps, in violation of American rights.

The issue at stake for these respondents is freedom, defined as the absence of deliberate (that is, conscious and planned) interference. When pushed, they will admit that urban growth left alone, may have undesirable, unanticipated consequences, but while undesirable, they are not "offensive," in that they came about by themselves.

The second group of respondents who see growth as determined by man and yet as inevitable argues that it is so because of those who are in power, both leaders and electorate:

> Given the existing decision-making structures, it's unlikely growth will be controlled. Those who enter politics do so to further their own financial interests and growth is necessary for that.
>
> The growth pattern isn't reversible with the people now in power in business and government. Like a locomotive, not stoppable. Professionals know that they're unanticipated consequences attending growth, but such people as make up the Chamber of Commerce don't concern themselves with those.
>
> This is a "growth-is-our-manifest-destiny" town. It would be politically impossible to be for something that's even perceived to be anti-growth.
>
> Atlanta is the California of 40 years ago, it draws out of the population those who want out of a stagnant world. As a consequence, the general public, which votes, is for growth, not just business. It's a popular view, everybody's raring to go.

It is important to emphasize here that although the respondents characterized by the above quotations view growth as logically controllable--that is, as within man's purview, they usually see it, practically speaking, as uncontrollable. For frequently, they see little realistic possibility of influencing the powers, however human, that dictate growth, or at least, permit it to occur.

These, then, are the main positions taken on the issue of growth. They are complicated by two factors, the first of which is logical inconsistency. Thus, those who held that growth was a force in and of itself, independent of man, nevertheless would occasionally speak of controlling or limiting growth, indeed, would express annoyance at the lack of actions taken. And those who held that growth was something created by business and politics, or rather, businessmen and politicians, would, nevertheless, occasionally despair over the impossibility of interfering with growth or limiting it or controlling it, and would speak of it as if it had a life of its own.

The second factor or group of factors complicating basic attitudes toward growth is what might be termed "causal refinements." For example, there are respondents who take the position, even among those who see growth as having been "set off" by man, that while growth can be interfered with, it cannot be intelligently and predictably interfered with. It is as if urban growth was some enormously complicated but perfectly balanced mechanism and to alter it at any particular point would cause deleterious unanticipated repercussions throughout the system. The free market pricing system is the analogy most often made.

In the end, the holders of the two basic conceptions of growth as a natural phenomenon and growth as "man-made" come together in agreement as to their belief in growth's "lifespan." This conviction that urban growth follows a pattern or a cycle was most often expressed as the belief that "when a city stops growing, it starts dying," or "there's no such thing as stabilization; if you're not moving ahead, you're falling behind." Again, the analogy most often used was economic; if the economy isn't expanding, growing, then it is in recession or depression.

There was never an attempt to explain why urban growth followed such a pattern, there was simply the conviction that it did. The only efforts at explanation were references to what had happened in "other cities"; in the respondents' eyes, there is empirical evidence in the history of American cities to persuade them that eventually growth tops out and the processes of decline inevitably begin.

Not surprisingly then, virtually all the respondents are in favor of continued growth. Important differences remain between them, however, regarding questions of how much growth, what kinds of growth, and the where and how of growth. And these differences relate back to the fundamental difference in how growth is conceptualized, already discussed. But overall, growth is seen as good, stability as impossible, and decline (in population and economic base) as bad.

What do the Atlanta respondents have in mind when they speak of growth as "good"? The economy, from various points of view, looms largest: increased job opportunities, increased tax base, increased profits--all amounting to "a higher standard of living for everyone." But there is an attitudinal benefit to growth as well: "A growing city is vibrant. Everyone is enthusiastic, people feel like they're on the move." It is growth that serves the American Dream.

But even the most ardent supporters of growth do not see it as wholly beneficial; there are some costs: increasing traffic congestion, pollution, urban blight and ugliness, misuse of resources, and most importantly, economic inequities.

And it is here, with the problems posed by continued urban growth and development that the respondents once again divide themselves; and they do so, generally, according to their original differences as to whether growth is seen as within or outside of man's control. Thus, those who see growth as determined by man tend to be those who are most aware of, and most concerned with, the undesirable consequences of growth. And they speak of controlling, limiting, directing, interfering

with growth to the end of lessening those effects. On the other hand, those who see growth as essentially beyond man's control, are more likely to minimize the social costs of growth, to shrug them aside (even while acknowledging them) as inevitable by-products of the process, and to adopt a hands-off policy on the logic that the benefits yielded by noninterference much outweigh the costs.

Tied to these differences, and ultimately behind them, are other ideological differences evoked by the discussion of growth. These are highlighted by examining the interview data with the following question in mind: Who is it that benefits most from growth, and who is it that feels most its undesirable effects? Those who would control growth, who would try to shape it, are those who perceive the benefits and costs of growth to be inequitably distributed. And their attempts to manage it are, in the end, attempts to keep those whom they see as powerful from enjoying unfair advantage over those whom they see as powerless. The "powerless" are of two types: First, there are those who begin life from "behind the starting line"; these are the "disadvantaged." These respondents believe that social facts--bigotry, poverty, ignorance--have produced such a disadvantaged group. Second, these same respondents believe the general public to be similarly powerless in that it is not organized, it has no lobby. (There is a lack of confidence in political representation.) Both groups of the powerless, the poor and the ignorant, and the unorganized public, must be "stood up for."

> Poor people are preoccupied by making their day-to-day existence--their interests have to be watched over by others.
>
> So-called "public participation" has to be done by those who have the time, energy, and interest--there isn't any mechanism by which the public as a whole can be represented on an environmental issue, except very late in the game by voting. This isn't the case for business or the Chamber of Commerce, or government agencies, for that matter.

In contrast, those who would let growth pretty much alone to go its own way are those who believe the benefits and costs of growth distribute themselves not unjustly but "naturally," that is, according to "merit"--defined as industriousness, intelligence, creativity, and character. People begin at the same place and are seen as getting ahead or not getting ahead by virtue of who and what they are themselves; and who and what they are themselves is not seen as a product of social forces but of individual character. The classic free enterprise system is applied to the growth process--the general good is served not by interfering with individual interests, but <u>through</u> their pursuit.

It is here, with this brief excursion into political and economical ideologies, that this discussion of limiting urban growth as a measure to conserve water ends. It is, of course, typical of inquiry into the realm of human attitudes for what appears to be a fairly straightforward question about urban growth to lead to issues concerning justice, free

enterprise, and democracy. While not wholly integrated or consistent, an individual's values and attitudes and beliefs are not independent of his judgments--they are connected, and putting pressure on one triggers others. And understanding of motivation and prediction of behavior increase as surface opinions are traced back to those values which appear fundamental.

Thus, the questions concerning urban growth yielded far more than data on that issue *per se*; an analysis of respondents' discussion of the issue identified important core values which have significance for the consideration of all water conservation measures.

Racial Antagonism, Distrust, Ignorance: Although no questions about them were asked, the interviews yielded information on three issues so frequently as to require comment. The first of these is the *awareness* of racial antagonism. Again and again the interviewees stressed that the political and economic powers of Atlanta that had once been fused are not separated. That separation is defined as economic and white versus political and black; it is seen as innately conflictual, as the aims of the two are different. For example, the white economic forces are perceived as wanting to keep taxes down as an incentive for city growth and investment; the black political forces are seen as wanting to increase government income so as to provide better services to the poor. In the minds of the respondents, blacks are associated with the stance that community good is best served by using government to *directly* tend to the needs of its citizens, and whites are associated with the stance that government should restrict itself to facilitating private enterprise which in turn would benefit the public.

Many respondents think that the growth of the city of Atlanta has been hurt by the shift in political power to the blacks and the resultant city policies. In their eyes, the white flight to the suburbs, especially of business, the climbing crime rate, and the "certainty" of increased taxation are either directly or indirectly connected with the transfer of power in city government to blacks.

Finally, there was some discussion of how racial competition was connected to the issue of urban growth on a personal, psychological level of white community leaders. The argument was that if growth was limited, the blacks would "take over"; that is, stabilization of urban growth would constitute an abandonment of power by the whites. In their logic, growth functions as the proof that the principle of "free enterprise"--benefitting all via the pursuit of self-interest--remains vital. If growth stops, there is concern that the principle of political interference in economic affairs (identified with blacks) would dominate. The dichotomy of race, then, is tied directly to the dichotomy of core values already identified in the discussion of growth.

It may be, then, that what is often identified by the respondents as a racial issue, really isn't; rather, it may be an ideological one. It is perceived as racial only because, rightly or wrongly, a particular ideology is associated with a particular race.

Two other issues that pervade the interview data can be quickly summarized. First, there is what can be termed "suspicion of the other's motives." Every group encountered apparently distrusts every other group. Thus, business suspects the city council, the city council distrusts the Chamber of Commerce, industry accuses the banks of promoting inter-city growth for profit, conservation groups accuse business of greed, the poor accuse the rich, the rich the poor, each race watches the other, the suburbs fear the city and the city scorns the suburbs. All groups are either angry or disappointed with government. It would appear that each interest group assumes that all others are impelled by selfish motives only and the common good has been abandoned by all.

Second (and certainly related to this atmosphere of mistrust), is the lack of knowledge each identifiable group has of the information held by other groups. The interviews are replete examples: (1) a white respondent is convinced that contracts associated with the building of the airport were given <u>only</u> to black-owned contractors; a black respondent dismisses such a statement as nonsense and cites examples to prove it; (2) representatives of conservation groups, concerned with the local environmental consequences of a possible reregulation dam, were unaware of the beneficial environmental effects such a steady flow dam might have on the downstream; (3) representatives of a major industry were unaware that Atlanta had no groundwater; they were also unaware of Public Law 92-500; (4) many respondents were unaware of Buford Dam's role in producing peak power; (5) many respondents anticipated conflict between the National Park's position on the Chattahoochee River and Lake Lanier and the position of those government agencies involved in augmenting Atlanta's water supply. One respondent commented: "They have never read the legislation creating the Park; it clearly states, and was so phrased precisely to avoid such a confrontation, that the Park cannot interfere with the use of such waters as sources of water supply"; and finally, (6) only a very few respondents were aware of what the alternatives were for increasing Atlanta's water supply.

To fully appreciate the import of this surprising lack of knowledge, it is necessary to remember that the interview respondents were not drawn at random from an untutored and unconcerned population. Rather, they were spokesmen for their groups. Compounding the issue is the fact that the groups represented by the interview respondents have representation on the Citizen Task Force of the Corps' Atlanta Urban Study which has met for briefings more than fifty times over the past five years. Perhaps an explanation for this seeming paradox of ignorance and misinformation lies in understanding the intensity of emotional commitment each of the various groups has to its own values and environmental position. Such commitments may make it difficult to hear other voices and easy to forget opposing arguments.

<u>Pricing</u>: Respondents were of two opinions, diametrically opposed, as to the effectiveness of price as a spur to <u>residential</u> water conservation. Both sides appealed to the same analogy to prove their point; on the one hand there was the argument that dramatic increases in the price of gasoline had had no effect on the amount of driving done, as the unlimited use of the car was seen as a necessity. On the other hand,

there was the argument that raising the price of gasoline was necessitating a reevaluation of car usage resulting in reduced driving and shifts to public transportation.

There was one "ultimate" point of agreement: those who said increased prices exerted little or no influence on water use acknowledged that this was so only "within limits," that is, the cost of water could be made prohibitive. And those who thought that price was an effective limiting factor on water use admitted that it must reach a "certain level" before it became so.

This level that price must reach for it to be effective complicates, for some, the use of it as a conservation measure. For instance, some respondents are against it because it would penalize large families--thus, in their view, it bears especially hard on the poor and the black, those "who can least afford it." Other respondents think that the price necessary to stimulate reduced use would have to be "artificially" high--that is, a deliberate interference into the price-establishing processes of the water market. They are, therefore, opposed to it on principle. Overall, however, the majority of respondents agreed that the squeezing of the individual citizen's pocketbook, if done hard enough, would reduce water use significantly.

This was not quite the case with industrial and business use. Most respondents began be asserting that, "of course," business and industry worked on a cost/benefit basis. Therefore, it was assumed that in their constant efforts to minimize costs, they had already reduced water use to that level necessary to their production. That is, many respondents assumed there was no waste, no margin for conservation to work. Given that assumption, they saw increases in water costs as having a variety of undesirable consequences--either the increased costs would be passed on to the consumer, or the industry/business would move, or the industry/business would fail to compete nationally or internationally and fail.

A fewer number of respondents did not have such faith in industry's past and current rational application of the cost/benefit principle. They thought that wasteful use of water was a characteristic of industry, especially since historically it has been so cheap, and that, because of the cost/benefit principle, they would be especially sensitive to any increase in price.

Here too, however, as with individual use, an ethical objection was frequently raised. If business and industry have come into the area or stayed in the area in part because of the cost of water, if, in effect, their economic viability rests upon anticipated water costs, then is it fair to increase their water costs; isn't that changing the rules midgame? Respondents concerned about this issue felt that to do so would be especially problematical for those businesses and industries whose goods and services competed in a "beyond-the-area" arena--that is, with competitors whose costs would not be subject to the same increase.

Renovated Wastewater: The respondents were unanimous in their approval of the idea of renovated wastewater as a conservation measure. They were also agreed that it was not now generally cost effective in the Atlanta area. There were several exceptions mentioned--a suburb badly in need of an increased water supply that had fortunately acquired sufficient acreage at a sufficiently low price to make land application feasible.

There was also general agreement regarding public response: There will be concern over such water's purity, but in the end, people will accept it either because they are rational ("people can face facts") or because they are compliant ("people will adjust to anything").

Lawn Watering: Most respondents feel that mandatory restrictions on lawn watering were inadvisable and ultimately ineffective as a means of conserving water. This conclusion stems from the opinion that such restrictions are inconsistent with the region's moist climate and verdant foliage. Lawn watering is thus seen as a relatively innocuous means of amplifying the "natural" beauty of the area. And any attempt to regulate it is seen as unwarranted interference with personal choice. (Such interference is thought to be warranted only in crisis situations or when the affected individual feels no impact--such as in the case of low-flow plumbing devices.)

The respondents feel that because of these attitudes mandatory restrictions would meet a great deal of public resistance and would be difficult and costly to enforce.

Despite the objection to mandatory restriction, many respondents realize that lawn watering is very wasteful because it results in unrecoverable runoff and evaporation. They object, not to the goal of reduced lawn watering, but to the proposed means of achieving the goal. Rather than making these restrictions mandatory, they prefer voluntary reductions stemming from a progressive rate structure and/or from a personal belief that reductions are necessary and morally right.

Plumbing Codes: Low-Flow Devices: The use of mandatory flow-reducing plumbing devices in new construction meets with almost unanimous approval of respondents. Because such devices save water while imposing no hardship on the individual, they are though to circumvent the philosophical quandary of whether or not it is acceptable to dictate personal preference in the home. In other words, such devices eliminate only wasteful usage of water while not affecting, in any way, the quality of life.

Such devices are also favored because of their so-called ripple effect. That is, in addition to saving water, they also conserve energy by requiring that less water be heated for showers and that less sewage be treated.

Despite overwhelming approval, certain reservations are expressed regarding the effects of these devices. First, because a large percentage of water and sewage treatment costs are relatively fixed, the reduction in water usage brought about by low-flow devices could result

in larger per-unit costs for the residential user and consequent public backlash.

Second, there is concern that these devices be economically equivalent in purchase price to the ordinary flow devices. Third, because such plumbing codes apply to new construction only, the effects of low-flow devices on water consumption are slow in coming and are in proportion to the growth rate of a particular area.

And finally, it is suggested that instead of assuming that water conservation results from these devices, careful in-home monitoring should be undertaken to insure that no compensatory water-use habits develop in response to the new devices.

Education: There is a great deal of variation among respondents regarding the effectiveness of education in conserving water. Representatives of certain conservation groups are the most sanguine about the issue. They feel that adults can be convinced that water conservation, by serving the common good, benefits the individual. Those holding this opinion assume a high degree of rationality in decision-making and the continued malleability of values throughout life.

Other conservation representatives feel that appeals to "the common good" are less fruitful than appeals to self-interest. ("People act only if you can show them that their ox is being gored.") Related to this point of view is the opinion that education regarding conservation affects different socio-economic classes differently. Specifically, it is suggested that the concerns of the poor are so immediate that it is nearly impossible to enlist their cooperation in anything but day-to-day concerns for survival. ("When you don't know where your next meal is coming from, it's difficult to be concerned with the water supply in ten years or even next year.")

The majority of respondents feel that attempts to foster in-home water conservation habits are largely ineffective in all sectors of the population regardless of "tactics" used. To effect appreciable change in water use most respondents feel that children would have to be socialized into a different world view, a different way of seeing man in relation to his environment. This socialization would not be oriented toward water conservation *per se*, but to general principles, such as "Abhor waste" or "Don't expect technology to be a cure-all for the world's ills."

Proponents of this view seem to appreciate the difficulty of such a major reorganization of societal values and are, therefore, skeptical of the facile shift exhibited by today's young people toward conservation. ("Turn off their air conditioners in August and they'll holler as loud as everyone else.")

Questionnaire Analysis

Introduction: In order to determine the response of the general public in Atlanta to water conservation, a questionnaire was mailed to a sample of 750 persons selected at random from the metropolitan Atlanta telephone book. This questionnaire presented eight water conservation measures thought to encompass the range of available measures. The measures presented in the questionnaire are:

A. Individuals install water-conserving plumbing fixtures.

B. Educational campaigns on how to conserve water.

C. Sewage reuse for industry and irrigation.

D. Building codes require installation of low-flow plumbing devices in new construction.

E. Pricing.

F. The city controls the urban growth rate.

G. Lawn and garden watering is reduced by half.

H. During drought, the government imposes mandatory restrictions on water use.

Respondents were asked to answer a series of questions about each of these measures. The questions are:

1. How much do you know about this water conservation measure?

2. How well do you think it would work?

3. How economical do you think it would be?

4. How serious would the need for water conservation have to be before you think it should be implemented?

5. Overall, how do you evaluate this conservation measure?

To maximize return rate, and to facilitate standardization of response, the questions were designed to elicit forced-choice response. Thus, for example, to question 1, "How much do you know about this conservation measure?" a respondent would check one of the following:

Nothing ________

A little ________

A fair amount ________

Quite a bit ________

In addition, a question was included to determine how favorably the respondent viewed government enforcement of conservation measures. And finally, information regarding the respondent's age, sex, and education was requested. A copy of this questionnaire is included in Appendix B.

Because of address changes, 136 of the questionnaires failed to reach their destination, resulting in a "net" mailing of 614. And of these, 114, or 19 percent were completed and returned.

In addition to this random sample of Atlanta's general public, questionnaires were sent to 200 individuals who, in the past, had expressed interest to the U.S. Army Corps of Engineers in water-related issues. This special interest group completed and returned 68 questionnaires, a return rate of 34 percent. This special interest sample was included in order to allow comparison of attitudes with the general public.

But surprisingly, these two groups differ very little in their responses to water conservation measures. In fact, the only significant difference between these groups is that the special interest group expressed more knowledge about seven of the eight conservation measures. The eighth measure, reduction of lawn watering, seems to be commonly known and was highly familiar to both groups. But on none of the questions regarding attitudes toward water conservation were there significant differences between the two groups. Therefore, although the conclusions reported below will stem from the survey of the general public, these conclusions are applicable to the special interest group as well.

However, it is questionable whether one can conclude from this similarity of samples that the attitudes of the general public toward water conservation are truly no different from the attitudes of those with a special interest in water-related issues. The extremely high educational level of those in the sample of the general public make this assumption tenuous. Two-thirds of this sample have at least a college degree and many hold advanced degrees. Also, it is likely that individuals interested in the topic of water conservation are more likely to respond to a mail survey than those not interested. And, hence, the results are, to an unknown extent, biased toward knowledge of and favorable attitudes concerning water conservation.

And the conclusions of this report are rendered further speculative by the nature of the questionnaire itself. The forced-choice format utilized in the questionnaire results in a useful but skeletal body of information. This format does not allow flexible interchange with the respondent and thus no clarifying questions can be posed. Ideally, then, these data would be enriched by interviews with the general public.

Despite the shortcomings detailed above, this method of inquiry can facilitate conceptual reformulation which often points the way for additional research. In the brief summary which follows, then, a few of the more salient findings will be presented, along with speculation concerning the causes and ramifications of the findings.

Rank Order of Conservation Measures: The eight conservation measures can be ranked according to the degree of approval they elicit from the general public in Atlanta. ("Overall, how do you evaluate this conservation measure?") Such a ranking, shown below in Table D-1, constitutes a thumbnail sketch of which conservation measures the public find most desirable and which measures are found least desirable.

TABLE D-1

ATLANTA WATER CONSERVATION MEASURES RANK ORDERED ACCORDING TO OVERALL EVALUATION

1. Building codes require water conserving fixtures
2. Sewage reuse for irrigation and industry
3. Educational campaigns
4. Individual installation of water conserving fixtures
5. Government intervention during drought
6. Lawn-watering reduced
7. Pricing
8. Control of urban growth

Table D-1 indicates that building codes requiring low-flow plumbing devices and sewage reuse are highly thought of, while pricing and control of urban growth are not generally favored as means of conserving water.

In order to understand what it is about these measures which accounts for this overall rank, it is helpful to also rank the responses to each of the four other questions asked of each measure, namely, the amount of knowledge about the measure, its perceived effectiveness, how economical it is thought to be, and how serious the need for water must be before a measure should be implemented (Appendix B, Questions 1, 2, 3, and 4). These dimensions, then, can be seen as contributing causes of the overall evaluation of a particular measure. And analysis of these components may enrich our understanding of a particular measure's high or low overall evaluation. These ranks are presented in Table D-2.

Examination of this array yields the following information. First, there is a marked lack of correspondence between how much a person knows about a measure and how highly he rates that measure overall. For example, building codes and sewage reuse, despite their high overall rank are rated 5th and 8th, respectively, in how much is known about them. Conversely, reduction of lawn watering, a measure with which the public is most familiar ranks only 6th in overall evaluation. Familiarity with a conservation measure is no guarantee of its perceived value. This finding casts doubt on the assumption that an effective educational campaign can convince the public of the value of a technically feasible conservation measure.

What factors, then, do account for a measure's overall rank? The single most potent predictor of a measure's overall evaluation is its perceived effectiveness; that is, how much water it is thought to save. Thus, when we examine the two highest and two lowest ranking measures in overall evaluation (building codes and sewage reuse vs. pricing and growth control), we see that three out of four of these measures occupy the same positions in perceived effectiveness. And the fourth measure, pricing, differs by only one position in perceived effectiveness.

At least two explanations exist for this strong association. First, it may be that the general public, in forming an overall evaluation of a conservation measure, considers first and foremost how effective it would be. In this view, a perfectly objective cost-benefit analysis results in a totally pragmatic determination of the value of a particular measure. Or, conversely, it may be that the general public's rating of the effectiveness of a measure is a function of its overall evaluation of the measure, an evaluation which, in turn, is determined by other factors. Implied in this position is the assumption that clear perceptions and rational processes are vulnerable to unknown influences from uncritically held belief systems.

Which one of these explanations is the more persuasive would have ramifications for efforts aimed at educating the public regarding water conservation measures. For example, if perceived effectiveness determines overall evaluation of a measure, then educational campaigns would stress potential savings of gallons per day and dollars per year. But if, on the other hand, perceived effectiveness is the <u>result</u> of

TABLE D-2

ATLANTA WATER CONSERVATION MEASURES RANK ORDERED ON FIVE DIMENSIONS OF OPINION

Conservation Measure	Knowledge	Effectiveness	Economical	Willingness to Implement	Overall Evaluation
Building Codes	5	1	2	2	1
Sewage Reuse	8	2	4	1	2
Education	7	7	7	3	3
Install Plumbing Devices	2	5	5	4	4
Severe Drought Govt Intervention	4	3	3	8	5
Reduce Lawn Watering	1	4	1	5	6
Pricing	3	6	6	6	7
Control of Urban Growth	6	8	8	7	8

evaluation, careful attention must be paid in educational campaigns to the "collateral" qualities of a proposed measure such as its convenience, equitability, and so on. Which of these alternatives is true is indicated by the fact that the correspondence between perceived effectiveness and overall evaluation is not very strong for middle-ranking conservation measures. Thus, for example, educational campaigns rank only 7th in perceived effectiveness but 3rd in overall evaluation. It seems, then, that the determinants of overall ranking are complex and require further elaboration.

Composite Favorability to Water Conservation; Distribution and Breakdown by Age, Sex, Education, and by Attitude Toward Government Enforcement: A score was computed for each respondent indicating how favorably, overall, he views the eight conservation measures presented. This score is obtained by averaging an individual's response to the question, "Overall, how do you evaluate this conservation measure?" Thus, an individual's average response can be summarized as "totally unfavorable," "somewhat unfavorable," "somewhat favorable," or "very favorable." Since this score is derived from an individual's response to a wide variety of specific conservation measures, it can be thought of as representing an individual's favorability toward water conservation in general.

As Figure D-1 shows, the response of the general public to water conservation is extremely positive. Over 90 percent expressed favorable attitudes toward the measures presented and only 15 expressed strongly unfavorable attitudes.

As mentioned in the introduction, this favorability is no doubt due in part to the response bias inherent in mail surveys. Nevertheless, the sheer magnitude of positive response leads to the conclusion that Atlanta's citizens are receptive to the general idea of water conservation and to many of its concrete representations. But whether this receptivity is readily translated into actual implementation of conservation measures is uncertain because although 90 percent approve of water conservation, two-thirds express only moderate approval while only one-fourth express strong approval. This seemingly minor difference in enthusiasm night take on significance if a proposed conservation measure would require active public support rather than mere passive acceptance (such as voluntary installation of low-flow plumbing devices, for example).

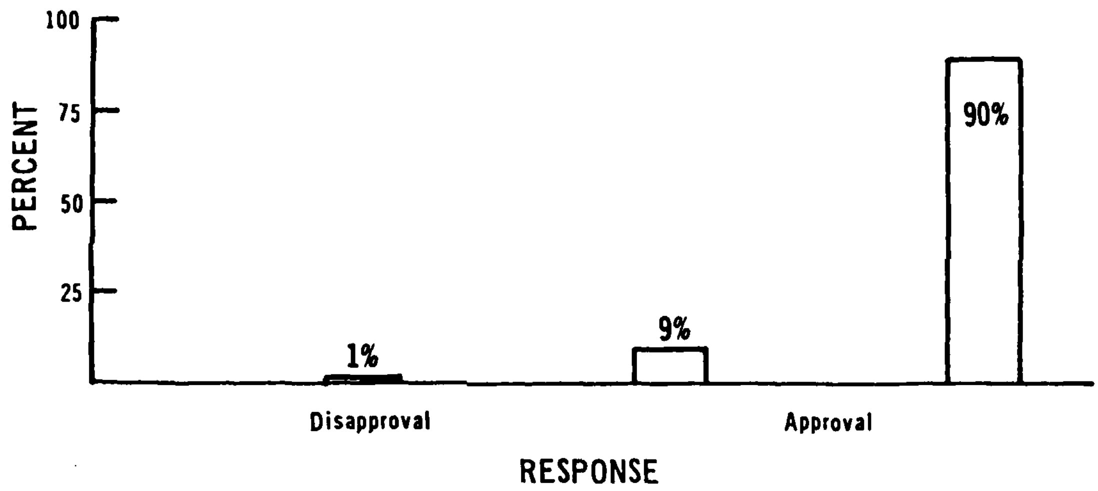
Further light may be shed on the nature of this public receptivity by examining the differences in this attitude associated with certain social characteristics. For, despite almost uniformly favorable attitudes, there are significant differences of degree associated with one's age and sex.

First, as Figure D-2 illustrates, the older one is, the less likely one is to exhibit favorable attitudes toward water conservation.

However, this general finding must be interpreted with caution. The age-related differences noted may be related in some way to the aging process itself. For example, these changes may represent a process such

FIGURE D-1

AVERAGE RESPONSE TO 8 WATER CONSERVATION MEASURES: ATLANTA



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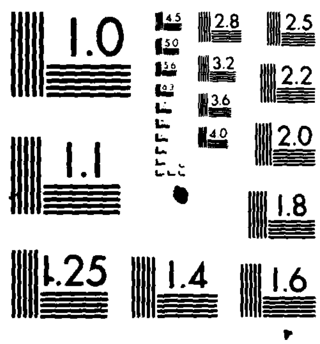
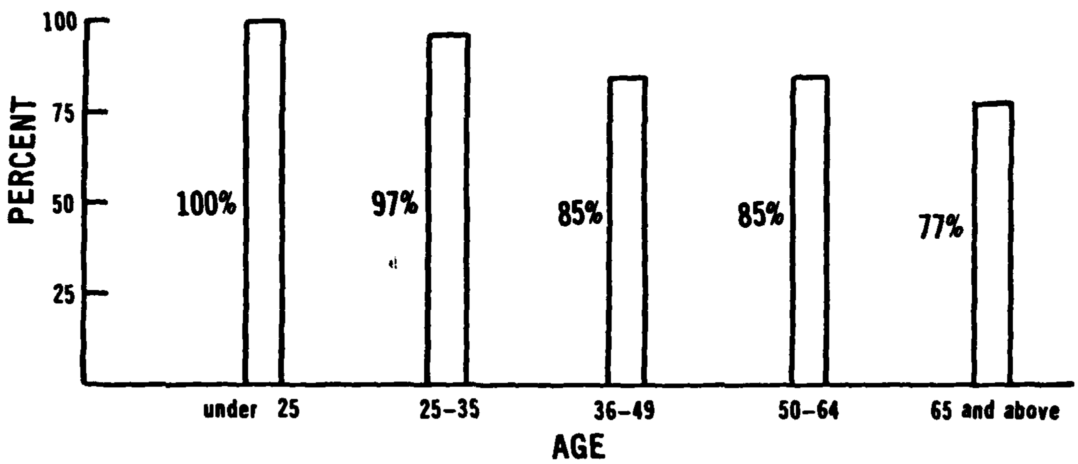


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FIGURE D-2

AGE AND FAVORABLE ATTITUDE TOWARD WATER CONSERVATION: ATLANTA



as the idealism of youth giving way to the pragmatism of adulthood. On the other hand, these differences may be the result of generational differences rather than changes which occur with age. In other words, different attitudes may have been instilled in these generations and continued unchanged throughout the lifespan. Hence, one couldn't assume, for example, that conservation-minded youth would grow less so with age. Long-range planning regarding water conservation would benefit from an understanding of which of these two principles is at work for water-related attitudes. And although these data alone cannot allow us to make this determination, in all liklehood these age differences in favorability reflect the increasing concern today with conservation issues in general, a concern associated with youth; indeed a concern which acts as a current generational rallying point for youth. But historically, the depth of concern represented in such movements has been suspect and, therefore, should be determined empirically rather than assumed.

Turning now to Figure D-3, we see that although 90 percent of both men and women respond favorably to water conservation measures, women actively favor water conservation by a 2 to 1 margin over men (40 percent of the women versus 18 percent of the men). And, as mentioned above, this difference in degree of enthusiasm may mean the difference between active implementation of a conservation measure and idle acceptance. This sex difference in propensity to action could, therefore, loom large if a proposed measure were aimed at water-using activities more often associated with a particular sex.

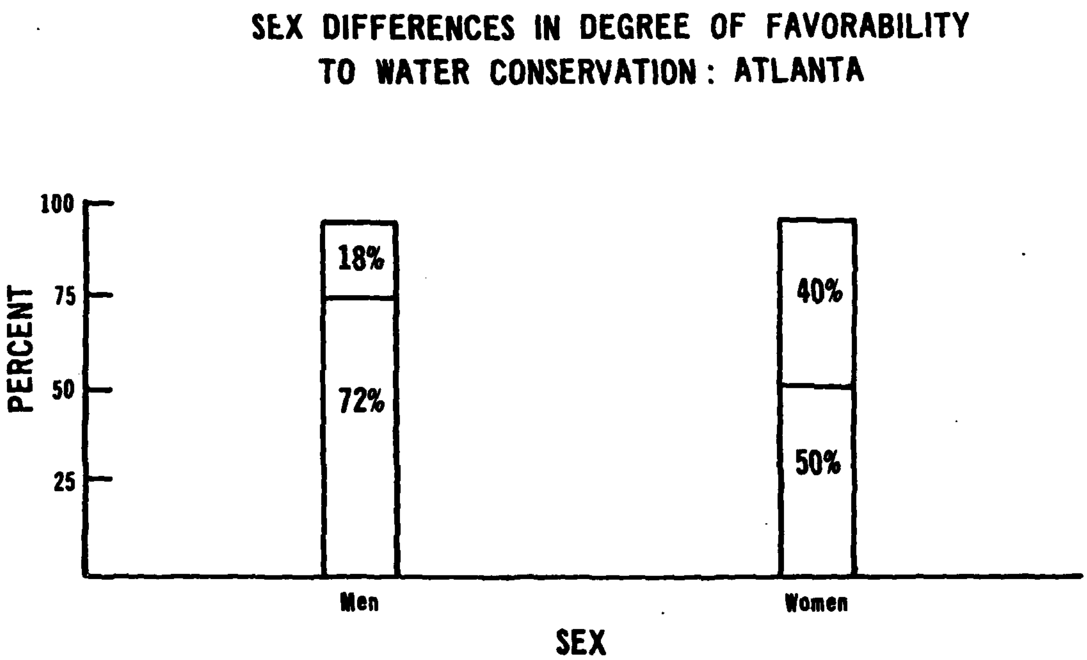
Thus, for example, a campaign which offers tax incentives to households which install low-flow plumbing devices would, in fact if not in intent, depend on the traditional male activities of tax management and home maintenance. But given the lack of enthusiastic support expressed by men for water conservation, it is uncertain whether sufficient motivation exists to ensure the success of this measure. This example is perhaps extreme, but it nevertheless illustrates the kinds of complexities which lie camouflaged in the term "high receptivity to water conservation."

Amount of education, a dimension often relevant when considering variation in attitudes, is not associated with how favorably an individual views water conservation. One possible reason for this lies in the unusual educational make-up of the sample. Not only is the sample highly educated (95 percent have at least some college), but the range of educational levels is relatively narrow--thus making the attainment of statistical significance more difficult.

Of course, this lack of significant association, rather than reflecting a sampling quirk, may reflect a true lack of relationship between how favorably water conservation measures are viewed and educational levels. With the population attaining higher levels of education, it is important for us to know more about this relationship, if there is one.

In addition to asking respondents how favorably they view the eight conservation measures, the questionnaire also asked how they would feel

FIGURE D-3


SEX DIFFERENCES IN DEGREE OF FAVORABILITY TO WATER CONSERVATION: ATLANTA
100
75
50
25
PERCENT
18%
72%
40%
50%
Men
Women
SEX

regarding government enforcement of these measures (see Appendix B). And despite the fact that, as a whole, the sample was far less enthusiastic about government regulation than about water conservation itself, the two dimensions are highly related.

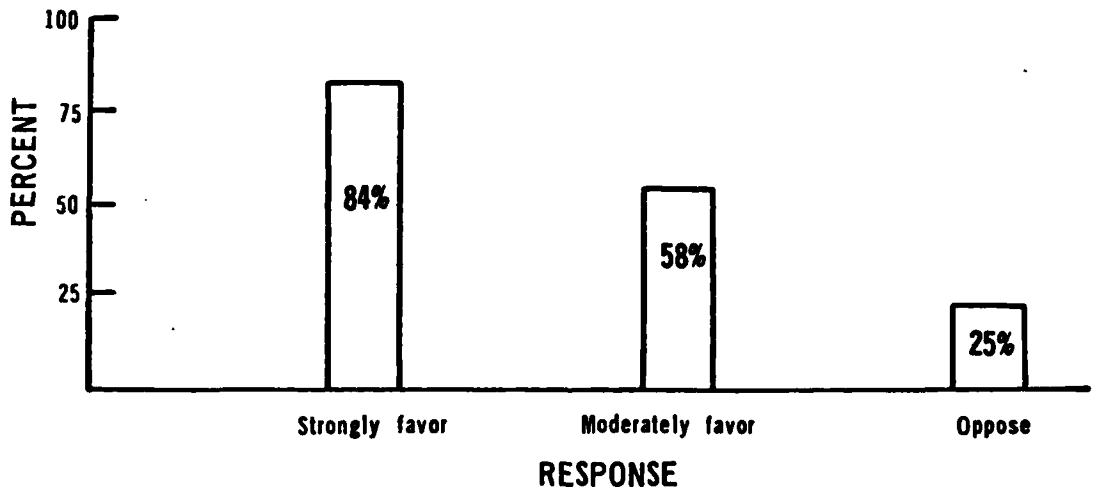
Thus, as Figure D-4 shows, of those who strongly favor water conservation measures, 84 percent are in favor of government enforcement of these measures.

But this favorable attitude toward government enforcement drops off to 58 percent even when we move down but one step in favorability toward conservation; that is, among those who express <u>moderate</u> approval of conservation. And it drops off to 25 percent among those who, on the whole, are opposed to water conservation. Perhaps the most revealing of these figures is that almost half of those who express moderate approval of water conservation oppose government enforcement of these measures. This seems to indicate that many individuals are unwilling to give up freedom of personal choice--even if dictated policy agrees with what they would do of their own volition. It is seeming contradictions such as these that indicate the power of the underlying belief system.

<u>Analysis of Response to Pricing and Reduction of Lawn Watering as Water Conservation Measures--Atlanta:</u> Let us now examine the response of Atlanta's citizens to two conservation measures, an increasing block price structure and the reduction of lawn watering. These two measures were selected for examination not because of their special relevance to the Atlanta area but rather because their analysis is illustrative of the general process by which the data concerning each of the water conservation measures can be translated into more usable information.

FIGURE D-4

RESPONSE TO GOVERNMENT ENFORCEMENT OF WATER CONSERVATION MEASURES AS RELATED TO ATTITUDES TOWARD THE CONCEPT OF WATER CONSERVATION: ATLANTA



Price: As Figure D-5 shows, over half of the sample knows little or nothing about pricing as a means of conserving water. But despite this lack of knowledge, the use of pricing as a conservation measure is still familiar to more of the public than are five of the other seven measures presented. These findings, indicative of a general lack of knowledge regarding specific conservation measures, are astonishing in light of the extremely high educational level of the sample and the emphasis on the concept of conservation in today's society. And consideration of the response to price itself reveals an equally striking fact. As Figures D-6, D-7, and D-8 indicate, the response to three specific questions about price is essentially identical: Slightly more than 50 percent think that price is effective in saving water, that it is economical, and that, overall, it meets with their approval.

Despite these moderately favorable opinions, the response to a related question regarding pricing is quite different. As can be seen in Figure D-9, 72 percent of the respondents feel that a water-conserving pricing system should be implemented only if the need for water is at least moderately serious.

This great hesitancy to implement, when contrasted with the majority view that pricing is an effective and economical conservation measure, may be explained in at least two ways. First, it may be, and very likely is, simply that people don't want their water bill raised. So, although pricing is perceived as effective and economical, this perception is insufficient to offset the increased financial burden which would result from implementation. Or, second, the concern over higher water bills might mask a more complex resistance to implementation. An increased water rate is an effective conservation measure only to the extent that it changes the way people think of water: Instead of water being seen as a God-given "right" of infinite abundance, it becomes a luxury. But a side effect of this "right" being taken away is that a change occurs in the way one sees oneself in relation to the world. Man's power is diminished. Instead of presiding over resources, he must now strike bargains with them as best he can. And the consequence of this necessity to now wheedle and cajole where once one commanded is a deterioration of status. Thus, with money and status at stake, it is no wonder that resistance to implementation is substantial.

Whatever the exact nature of the cause for this resistance, one might conclude that it is pervasive throughout the population because there are no age, sex, or education differences in opinion on any question regarding price. Tentative conclusions such as these should be used to guide further inquiry.

Lawn Watering: Turning now to public response to lawn watering, we see a similar inconsistency between perceived effectiveness and desirability of implementation--only more so. As Figures D-10 and D-11 show, 77 percent of the sample think that reduction of lawn watering would be effective in conserving water and 82 percent think that it is an economical measure.

These figures are 20 percent higher than the corresponding figures for pricing. Thus, according to these "pragmatic" criteria, lawn watering is viewed favorably by substantially more of the public than is

FIGURE D-5

KNOWLEDGE OF PRICE AS A WATER CONSERVATION MEASURE: ATLANTA

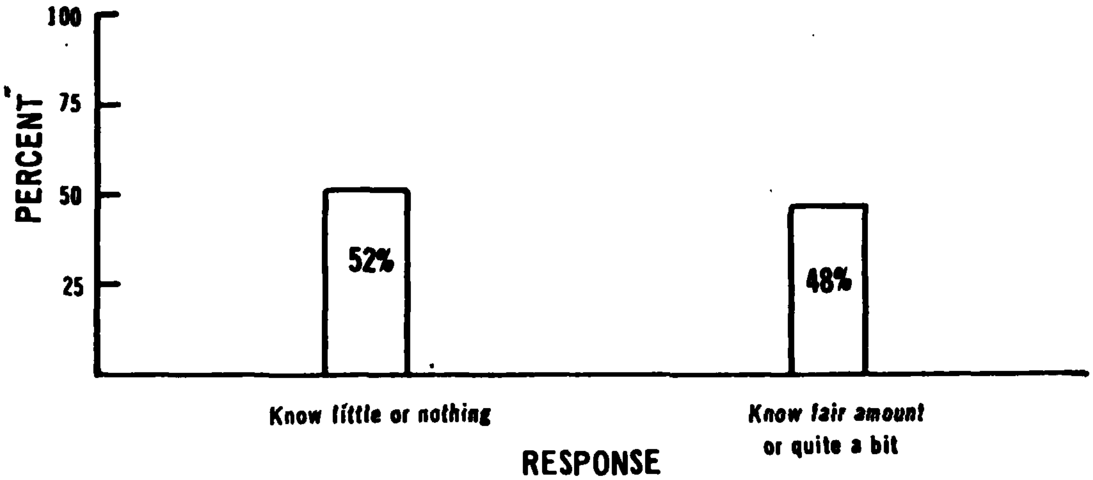


FIGURE D-6

PERCEIVED EFFECTIVENESS OF PRICE AS A CONSERVATION MEASURE: ATLANTA

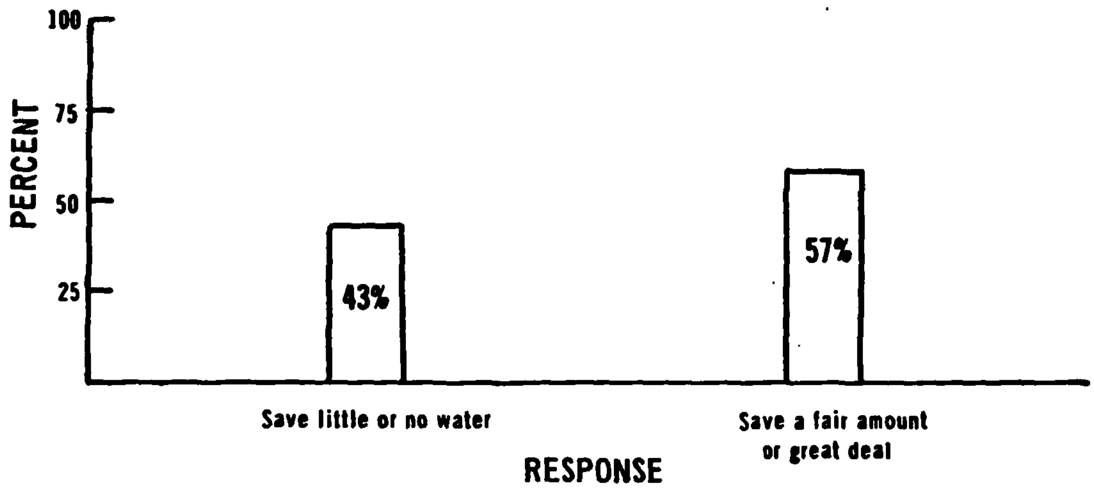


FIGURE D-7

PERCEIVED NET ECONOMIC EFFECT OF PRICING AS A WATER CONSERVATION MEASURE: ATLANTA

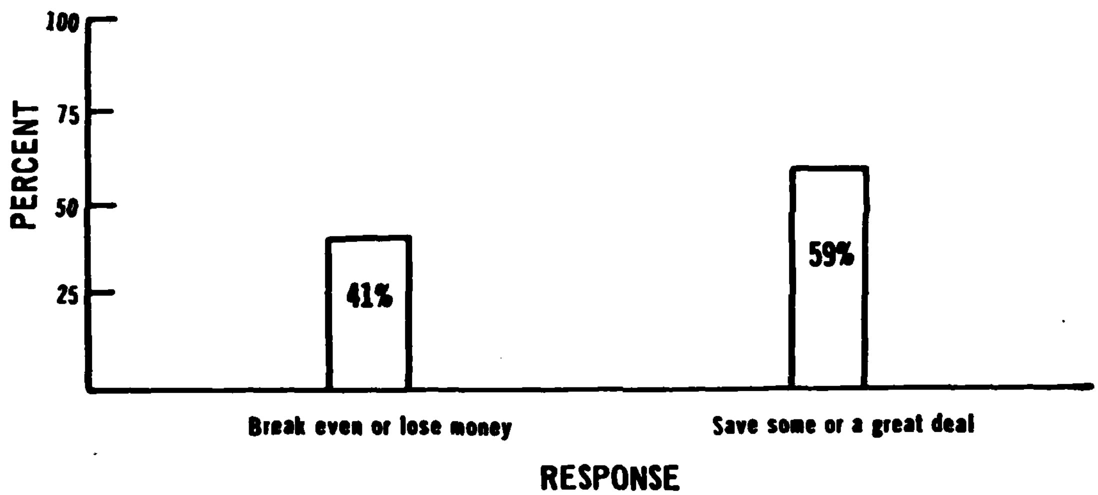


FIGURE D-8

OVERALL EVALUATION OF PRICE
AS A WATER CONSERVATION MEASURE: ATLANTA

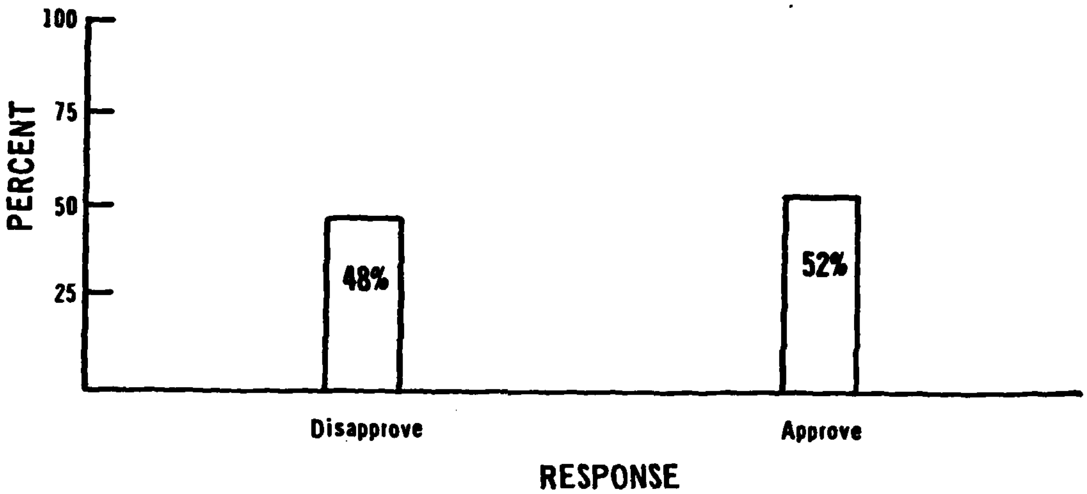


FIGURE D-9

WILLINGNESS TO IMPLEMENT PRICING AS A CONSERVATION MEASURE AS TO HOW SERIOUS THE NEED MUST BE: ATLANTA

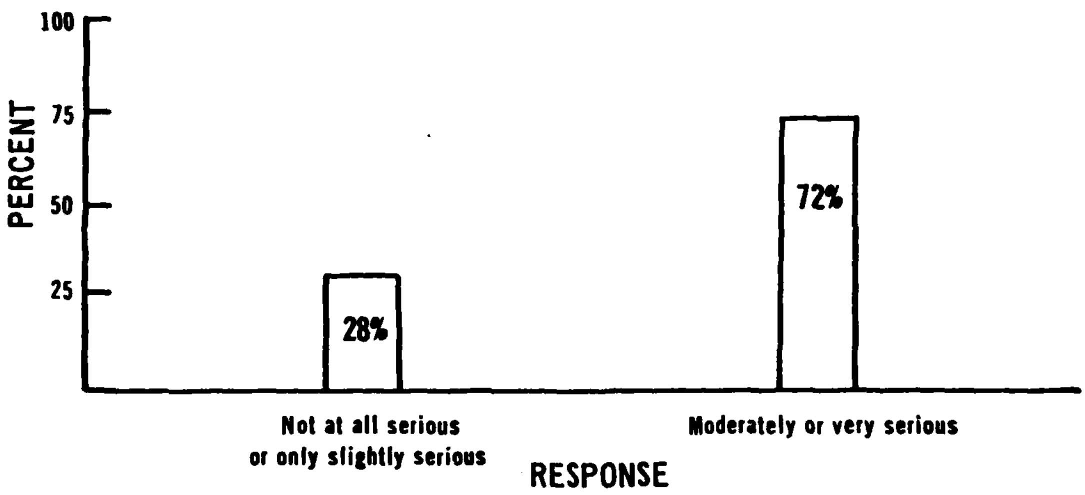


FIGURE D-10

PERCEIVED EFFECTIVENESS OF LAWN WATERING REDUCTION AS A CONSERVATION MEASURE: ATLANTA

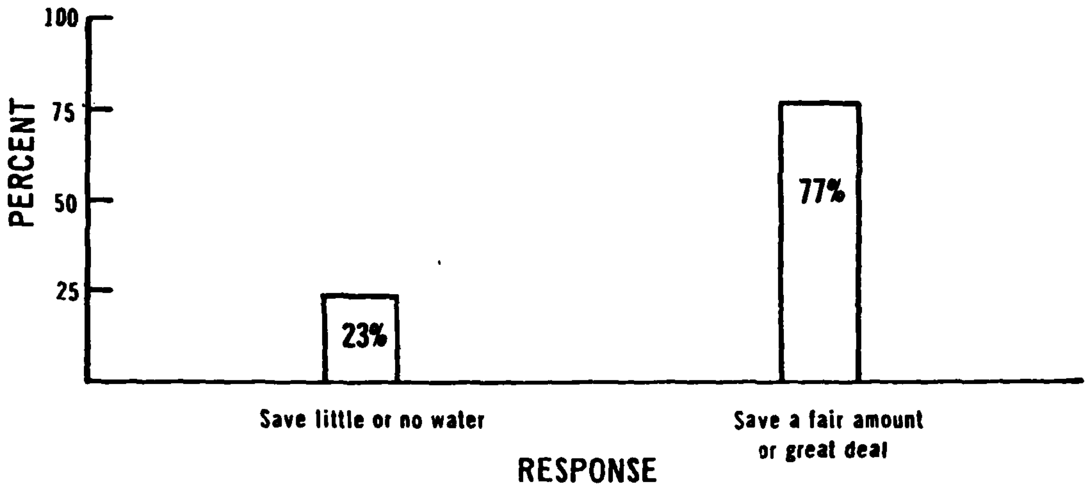
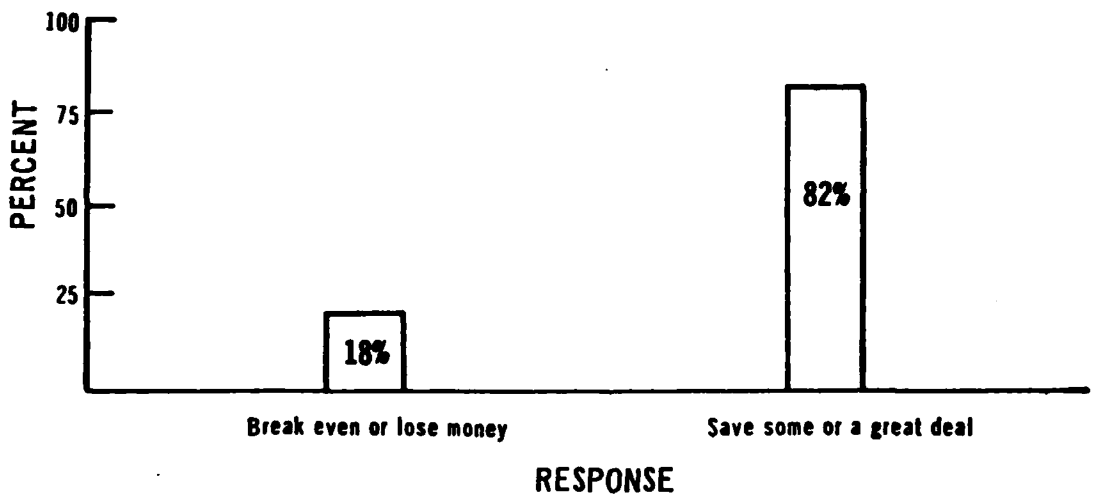


FIGURE D-11

PERCEIVED NET ECONOMIC EFFECTS OF LAWN WATERING REDUCTION AS A WATER CONSERVATION MEASURE : ATLANTA



pricing. One might, then, expect to find a correspondingly higher proportion of the public expressing favorable attitudes toward implementation as well. But instead, these differences are levelled when actual implementation is considered. As Figure D-12 shows, 69 percent of the sample believe that the need for water must be at least moderately serious before reduction of lawn watering should occur. Referring back to Figure D-12, we are reminded that the corresponding figure for pricing was 72 percent. Thus, this similarity of attitudes regarding desirability of implementation in the face of substantial differences in perceived effectiveness of two measures lends strength to the hypothesis that certain deeply valued beliefs are at work.

But in contrast to public opinion regarding price, which did not vary by age, sex, or education, the willingness to implement reduction of lawn watering decreases significantly with age. Thus, as Figure D-13 shows, 47 percent of those under the age of 35 are willing to implement reductions if the need for water is only slightly serious or not at all serious. This compares to 28 percent of those between the ages of 36 and 50 who are willing to do so, and to a scant 9 percent of those over the age of 50.

These findings raise a question. Why, if there are no age differences in perceived effectiveness of watering reduction, are there age differences in willingness to implement this measure. There are at least three possible answers to this question. First, it may simply be that younger respondents are more likely to live in apartments and therefore would have less to lose if watering restrictions were implemented than would older respondents who tend more to live in houses and thus have a lawn. Second, this age difference in willingness to implement may represent attitudinal differences resulting from different educational levels of different generations. And the data do indeed support this hypothesis, but only to a slight degree. Third, it may be that reduction of lawn watering encroaches in some widely held value, but one which is held less strongly by younger respondents than by older respondents. For example, it may be that as one ages, one cherishes the beauty of nature more and one desires to nurture this beauty. And therefore, despite the fact that people of all ages view this measure as highly effective in conserving water, older people see this effectiveness as insufficient reason for implementation.

<u>Response to Government Enforcement of Water Conservation Measure, Atlanta:</u> In the formulation of water conservation policy, it is crucial to determine who should be responsible for the implementation of the agreed-upon measures. And it cannot be assumed that all means of implementation are equally acceptable--even if the measure itself is seen as highly desirable by the public. To this end, respondents were asked whether they approve of or oppose government enforcement of certain water conservation measures. And although there were no significant differences of opinion on this issue according to one's age, sex, or education, a wider range of opinion was expressed (see Figure D-14).

Perhaps the most striking aspect of this response is the substantial proportion of the respondents (39%) who express opposition to government enforcement of water conservation measures. This is especially

FIGURE D-12

WILLINGNESS TO IMPLEMENT LAWN WATERING REDUCTION AS A CONSERVATION MEASURE: HOW SERIOUS MUST THE NEED BE: ATLANTA

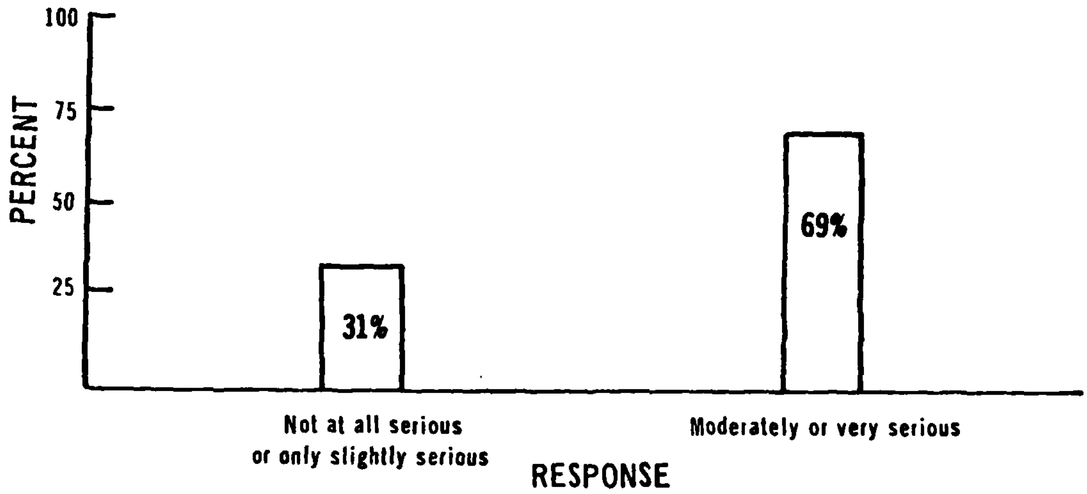


FIGURE D-13

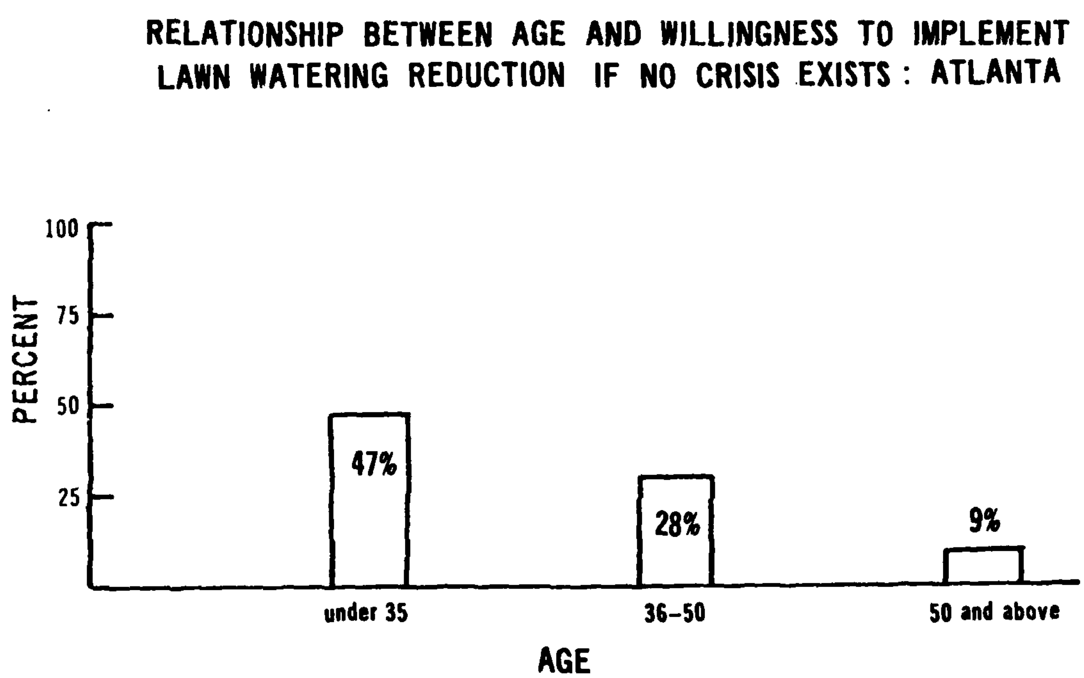
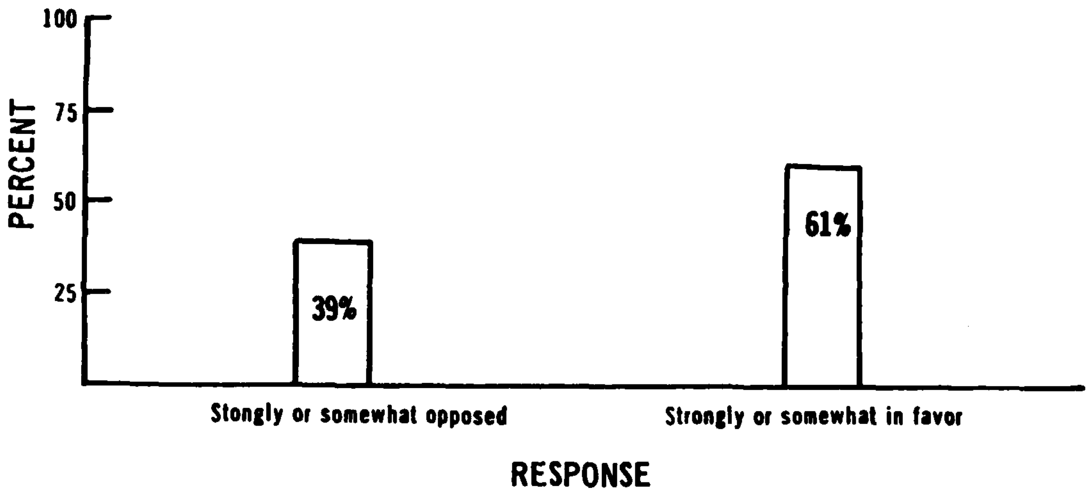

RELATIONSHIP BETWEEN AGE AND WILLINGNESS TO IMPLEMENT
LAWN WATERING REDUCTION IF NO CRISIS EXISTS: ATLANTA
PERCENT
100
75
50
25
47%
28%
9%
under 35
36-50
50 and above
AGE

FIGURE D-14

RESPONSE TO GOVERNMENT ENFORCEMENT
OF WATER CONSERVATION MEASURES: ATLANTA



noteworthy in light of the fact that 90 percent of the sample view the conservation measures themselves favorably. In other words, a water conservation measure may be perceived as effective, needed, and just and yet meet with opposition if it is government mandate. One explanation of this means-end discrepancy is that government enforcement of behavior in areas that have traditionally been "governed" by personal choice is seen as violating not only what is fair, but what is natural as well. And this violation is considered serious enough by many to countermand a highly valued water conservation measure.

The importance of this issue should not overshadow the fact that the majority of the sample (61%) expressed favorability toward government enforcement of water conservation measures. Differences of opinion on value-laden issues such as acceptability of government enforcement can be further investigated by determining the attitudinal and/or demographic correlates of the positions involved.

For example, one would want to determine whether favorable attitudes toward government enforcement results from strong belief in water conservation itself a sort of "threshold of conviction" concept. If so, then focus could be placed on somehow convincing the public of the value of the measures themselves. And, pari passu, attitudes toward government enforcement would follow. If, on the other hand, attitudes toward government enforcement are independent of the strength of one's belief in water conservation, an entirely different strategy would be required.

Refinements such as these are necessary if we are to progress from a mere realization that caution must be exercised in considering social acceptability to a point where general guidelines for action can be drawn with some assurance.

Implications of Results

Perhaps it should be reemphasized here that the goal of a study of the social acceptability of water conservation measures is something short of predicting community response with certainty. Rather, such inquiries must be satisfied with probabilities and a study should be considered successful if it raises the confidence placed in such judgments of probable community acceptance or rejection. The purpose, then, of a social acceptability study, is to inform the U.S. Army Corps of Engineers of community values, attitudes, beliefs and feelings so that its policies and programs may be based upon such social realities just as they rest upon the realities of technology and economics.

How is the understanding of the community to be used? The process involved can perhaps best be described by a series of questions: How does the conservation measure being considered fit with what have been identified as central ideologies of the community? What special interest groups can be expected to support it? And who will oppose it? What are the relative strengths of these groups? How will the public respond to it? Are there ways of presenting the measure or of redefining it or modifying it so that it would be perceived as not only in line with but as promoting a community value? This is the kind of dialogue that uses what was learned from the study.

Of course, such analytical conversations are long and detailed, and logically each and every possible conservation measure could be so examined. However, we are here interested only in illustrating the process and a consideration of two specific conservation measures will suffice.

Pricing: A review of the interview response specific to increased pricing as a conservation measure emphasizes several points: (1) Increasing block rates must be considered separately for residential and business use as different issues are involved; (2) Everyone agreed on its potential effectiveness for reducing residential demand; (3) The strongest objection raised to application of the measure to residential water use was that it would bear hardest on those with large families, and therefore, on the poor and the black; (4) Two objections were raised to using the measure in business and industry--as distinct from residential use: The position was taken that there was no margin of waste on which it could work its effect, and second, it was perceived as constituting an unfair shift in the "rules of the game," that is, in the anticipated costs of production.

These points emerged from an analysis of responses to direct questions on pricing as a conservation measure, and they are of commensurately direct relevance. But their meaning expands and their importance grows when connected to the broader ideological issues revealed by the respondents in their discussion of urban growth.

For example, we learned that one major ideological position appearing in Atlanta was the belief that the benefits and costs of growth are inequitably distributed; if left to itself, if uninterfered with, growth tends to benefit the rich and cost the poor. Respondents holding such a position felt that government should intervene to counter such inequities with programs, such as the progressive income tax that works on an opposite principle, namely, to place the greater economic burden on those who can afford to pay it.

Thus, the objection to increasing block rates as possibly placing a disproportionate burden on the poor is not an isolated one; it is, rather, a manifestation of a general ethic, of a deeply felt commitment to a specific definition of fairness--fairness defined as equity.

Further, although there are many groups that would hold these values, perhaps the one of most current importance would be the leaders of the black community; leaders who, at the same time, head the city government.

It would appear, then, that the prospects of the use of substantial increasing block rates as a measure to effect conservation would be greatly enhanced if the proposal could somehow avoid the charge of placing an added burden on those least able to bear it. If not, considerable general opposition could be easily mobilized, for the ideological base of the objection is widespread, and, perhaps of even greater immediate consequence, most probably the powers of local government could be easily mobilized against the proposal.

How this might be done is a challenging question and certainly beyond the scope of this report. But the point here is the warning, the awareness of the need to confront and handle an ideological consequence of pricing if the measure is to enjoy a high probability of being socially acceptable.

Data from the questionnaire raise a further possible constraint on the use of increasing rates as a conservation measure: It is not popular with the general public of Atlanta--ranking 7th out of 8 measures in overall acceptability. Many see it as neither effective nor economical. Almost certainly these assessments result from a conviction that the current level of water use is a necessity; the argument would run that no matter what the price, people would have to use as much water as they do now, hence, no saving either of water or of money. Interestingly, this is the same logic that the community influentials applied to pricing in business and industry, namely, that there exists no margin of waste on which pricing could operate. This belief constitutes an additional challenge to the use of pricing as a conservation measure. Again, awareness of it presents the opportunity to deal with it.

The question of the use of increasing block rates in business and industry is related to a different set of ideological concerns. The judgment, or more accurately, the belief held by most respondents that business and industry do not waste water is neither an isolated assessment nor is it one based on evidence or experience. It is, rather, essentially a deduction which follows from the general placement of trust in the economic rationality of free enterprise, of trust in the principle of maximizing profits by minimizing costs. The assumptions, then, are two: First, there is the assumption that such a "law" is, indeed, being applied, and two, that its application will result in using only that amount of water that is necessary.

A corrolary to that belief, to that confidence in the operation of an economic principle, is a policy of noninterference. Government (or for that matter, public utilities which are often seen as quasi-governmental) ought to stay out of the picture and let the market operate unto itself.

These are powerful beliefs held by powerful forces in Atlanta; efforts to implement the use of increasing rates as a conservation measure in business and industry would be wise to acknowledge them. Their support or opposition would depend heavily upon how the measure was seen--as an arbitrary and unwarranted intervention into the economic arena, or as itself a result of the operation of market forces. In the latter case, price increases, although perhaps unwelcome, would at least be "legitimate"--that is, in tune with a social ideology.

Plumbing Appliances: The use of low-flow toilets and shower heads as a water conservation measure is of especial interest in Atlanta because it is on the brink of implementation there. Through the initiation and support of the Atlanta Regional Commission, the state legislature has enacted a law requiring the use of such plumbing appliances in new construction as of 1980. Rather than attempting to analyze the future, to anticipate possible response to the proposal of a conservation

measure, it is here possible to attempt to analyze the past, to explain the response that led to its adoption; rather than the question, is it socially feasible, the question becomes why was it socially feasible.

Those interview respondents in Atlanta who were involved in the law's passage provide long and detailed explanation--from the gathering of data to back the argument of the measure's potential effectiveness, to the political machinations in the state house. All of such history is undoubtedly relevant; however, the focus here is on how the measure fit into the main ideological currents that characterize the Atlanta community.

From that perspective, two questions immediately arise: (1) Why wasn't the law seen as lowering or "taking away" that amount of water defined as a necessity; and (2) why wasn't the law seen as a direct government intervention into the market place. The answer to the first is that the reduction in amount of water use achieved by such appliances is assessed as being essentially unnoticeable; that is, although the user of the shower or toilet is intellectually aware that less water is being used, his senses do not distinguish the lowered levels; both plumbing devices will be experienced as they had been. The expectation, then, is that the quality of life, as far as water use is concerned, will be unchanged. Thus, the law does not constitute a threat to a standard of living made sacred by habit.

Data from the survey support and expand this conclusion--of the eight conservation measures they reviewed, the public sample gave plumbing codes its highest overall evaluation. And this first ranked status rests not only upon its being seen as effective (89 percent) and economical (82 percent), but also upon the fact that it is seen as generally acceptable, that is, only 9 percent of the sample required that a serious water shortage be a condition for its implementation.

The second question concerns the law as a possible incursion into free enterprise. To begin, although indeed plumbing codes do act as constraints on business and industry, they are not perceived as interventions of the same order as pricing. To set price for the purpose of conservation is to directly tamper with the economic laws of the market; to set codes is merely to establish the conditions within which economic laws can continue their automatic operation.

The codes also avoid another pitfall--they do not hit the pocket-book of the construction industry. A low-flow fixture costs pretty much the same as a standard fixture and the labor costs to install either also remain constant. Thus, the switch-over is not at anybody's expense.

It should be noted that the one group that could have suffered economic harm--plumbing manufacturers and supplies with large stocks of standard fixtures--were more than adequately represented in the legislature. The resolution was reasonable and easy: delay the date of mandatory implementation until inventories could be liquidated. Again, this maneuver can be seen simply as a political expedient. Certainly, it was that; but at the same time it was more than that--it was an example

of a condition that successfully moved the measure ideologically away from a conflict between business and government.

Of course, it is easier to determine the social feasibility of a conservation measure after its acceptance than before; ex post facto analysis tends to be convincing. But it should be realized that the attempt to explain the achieved fate of a conservation measure serves essentially the same purpose as attempting to predict what the fate of a measure will be, namely, practice in speculating on the degree of congruence between a prospective measure and the social ideologies that determine, in important part, its social feasibility.

APPENDIX E

CONTRACTOR REPORT ON SOCIAL ACCEPTABILITY OF WATER CONSERVATION MEASURES IN TUCSON

SOCIAL ACCEPTABILITY

It would appear obvious that the ultimate purpose of a study on the social acceptability of water conservation measures is, by definition, the determination of whether certain measures are or are not socially acceptable, that is, acceptable to the community in which they are proposed. But unlike the determination of technical or even economic feasibility, such clearcut decisions are rarely (if ever) attainable in the area of community acceptance. Both the number and complexity of factors involved preclude the prediction of community response with certainty. The goal, then, of such efforts is a more modest one: to increase the quality of the judgments made as to the probable response a community will make to a proposed measure.

Community response to a conservation measure is, in important part, a function of its congruence with the community's dominant social ideologies. The question is: Is a specific measure perceived as being harmonious with those basic values, beliefs, attitudes, and feelings that define a community's commitments, or is it seen as in some way violating them? In so far as progress is made in answering that question, one's judgment as to the social acceptability of the measure improves.

It is clear, then, that to serve the ultimate purpose of making such judgments, it is necessary first to achieve some understanding of those ideological themes in a community that are of relevance to conservation. Thus, the immediate goal of a study to determine the social acceptability of conservation measures is the *identification and delineation of those* community values, beliefs, attitudes, and feelings that will influence its response to any and all measures.

The studies of social acceptability reported here used interviews with persons perceived by citizen advisors as exercising considerable influence in the community, and mail questionnaires with a representative sample of the general public. In both cases several kinds of issues were discussed. The relevance of obtaining the evaluations of respondents to specific conservation measures that might be proposed in the future is self-evident. But what might be less immediately understood is the rationale for raising matters in these discussions that, at best, may be seen as only tangentially related to water conservation, and, at worst, would appear to be totally unrelated. Examples of such issues are water rights, alternatives for increasing water supply, or the question of inhibiting or fostering urban growth.

Indeed, such issues do not constitute conservation measures. The discussion of them is, rather, a means to an end. For it is by way of their consideration of such issues, often somewhat controversial, that respondents reveal those values, beliefs, attitudes, and feelings that characterize their social ideologies. Thus, although the restriction of urban growth may not be a possible conservation measure (and certainly not one on which the U.S. Army Corps of Engineers would take a position), discussion of it may well produce the clearest picture of those values and principles of judgment that the community uses in its evaluation of any and all conservation measures. In other words, discussion of such

issues is often, indeed usually, more successful in leading to the identification and delineation of basic values than is the discussion of specific and circumscribed conservation measures.

It must be reemphasized that the immediate goal of a study on the social acceptability of conservation measures is to understand the community, to put your finger on its pulse, to get a feel for the various forces at work with it, to know who holds what values and why. For it is only such an understanding-in-depth that can serve as an enduring base for judging community response to any specific measure.

One last point should be made before proceeding to the Tucson data. The interviews were conducted so as to provide the respondent with a forum in which to present his ideas and feelings as freely and openly as possible. The analysis seeks to preserve the resultant unrestrained and often emotional quality of the respondent's position; for in understanding social ideologies, the strength and quality of the affect that is associated with a position is as important as the substantive aspect of the position itself. It need hardly be added that the views expressed in the data, as well as the passions with which they are held, are totally disassociated from the U.S. Army Corps of Engineers itself.

Growth: In Atlanta, it was the discussion of the issue of urban growth that proved to be of most relevance in identifying the underlying values of that community. But there, some analysis, some interpretation was necessary in order to penetrate to what might be termed core philosophical stances. Again, in Tucson, it is the subject of growth that leads to an understanding of the fundamental value of the community. But here, in contrast, the route is remarkably direct; there are few if any inferences to be drawn; the style of the interview respondents is simple and blunt--appropriate to the black and white contrasts in the content of the beliefs they expressed.

In Atlanta, while there were differences between various interest groups on the nature and causes of growth, in the end all forces were allied to promote it. What continued to importantly differentiate among them were the principles according to which growth should operate, according to which the benefits and costs of growth should be distributed. There were those in Atlanta who were more or less on the side of the political process being used to control growth; implicit was their judgment that the free enterprise system is the basis of social and economic justice.

But, as the phrase "more or less" implies, these were philosophical polarities reached only by the logical extension of what was said. In actuality, Atlantans were "moderates"; those who faulted the system of free enterprise were not opposed to it; they believed in its virtues and wanted only to temper its effects. And those who asserted free enterprise's virtues were nonetheless ready to accept, indeed, to demand some interferences with its processes. The voices of both sides were muted by a mutual uneasiness that neither position could be held absolutely.

Not so in Tucson; positions there tend to be extreme, and there would seem to be little appreciation of the "other's" side that would modify one's own position and lead to tolerance of another's views, or to compromise. Ideologies are stated boldly and fervently; there is little sense of the subtle complications that give pause. The opposing ideological poles, then, that are illuminated by the respondent's discussion of urban growth or its limitation can be clearly delineated.

The dominant value system in Tucson (congruent with what one respondent called "our state's senator and our state's right-to-work law") is the utter belief in the justice of the benefits that result from free enterprise, from the operations of the free market. It is this economic model of the free market that is generalized to serve as the principle according to which all social processes should operate. Thus, the limitation of urban growth as a possible conservation measure is not even conceivable, as growth must be allowed to either happen or not happen "as it will." Any use of political power--to shape, mold, or control growth--is to be avoided, since rules and regulations on growth would only interfere with what is seen as a self-regulating process, as "natural" and effective and as responsive as "price" is to the law of supply and demand.

This ideology is illustrated by the following interchange between a respondent representing agricultural interests and the interviewer. The respondent spoke of growth in Tucson as follows:

> When you've dealt with weather--temperatures, wind, rain, the Spring frost date, the Fall frost date--these uncertainties, you know you have to submit to external forces--that's the way it is with city growth.

When this conception of growth as an uncontrollable phenomenon was challenged by the interviewer, the respondent's answer was that growth was a market phenomenon and therefore it shouldn't be controlled, not only because it is "wrong" to do so, but because it would be disastrous to do so. He cited an example of such interference:

> Henry Wallace and the Agricultural Adjustment Act of 1933. They slaughtered thousands of hogs and buried them, even though people in the cities were hungry, just to bring the price up.

Asked about the fate of those farmers had such steps not been taken, he replied, in effect, that whatever would have been their fate should have been their fate.

The interviewer then confronted him with the argument, met with frequently in Tucson, that in the competition for water with the cities and industry it is the farmers who will eventually lose because they do

not contribute commensurately to the economy of the state. Unhesitatingly, he agreed:

> Only those farmers who can compete economically for water will survive.

And it was clear that implicitly he had added--or should survive. To hold such a position in the face of what is seen by farmers themselves as an inevitably worsening situation for agriculture is indicative of the strength with which the ideology is held.

This very strength and purity of ideology raises two questions with the respondents holding it, the first of which centers on logical consistency. If nothing should interfere with the freedom of the market, then what of those economic advantages enjoyed by agriculture and which derive from their historical, and indeed current, political power--water rights, low electric power rates, anticipated CAP rates, and so on? The rationale given in response to such a question is that such advantages, regardless of the rightness or wrongness of their origins, are now economic givens; they were the realities on which the cost/benefit analyses that determined agricultural investment were based, and to give them over now to the play of purely economic forces would constitute an unfair change in the rules of the game.

The second question to ask of respondents holding such a "free market" ideology concerns the effects of applying an economic principle to other realms of social endeavor--for instance, politics. To establish the limits of the beliefs held by the respondent already quoted, he was questioned about the logic underlying "affirmative action." The fact that he was against what he saw as an attempt to redress past wrongs committed against one group by committing current wrongs against another is, of course, important; but, more important was the fact, made clear in his discussion, that the conception of socialized disadvantage, that is, that persons may be shaped in part by social forces over which they have no control, was alien to him.

However, without such a concept, the group that came to his mind when affirmative action was mentioned, Indians, posed problems for him. On the one hand, his reading of history had persuaded him that the Indians had been "wronged," and indeed, he teetered on the brink of saying that their present difficulties were because of that history. But such a causal system would have contradicted the assumption of everyone starting equal that is necessary for the logic of the market to be just. And to permit that would have raised doubts about the logical applicability of the free market principle to social facts. The discussion moved on.

This single interview, while unique in style, captures what is the ideological essence of the majority of Tucson respondents--whether farmer, homebuilder, banker, or politician. It was rarely stated with such conviction, but whatever the guise or tone, it appeared again and again. Thus, one respondent characterized Tucson as "not socialistic," and, when asked to clarify, said that Tucsonians were not proponents of the redistribution of wealth: "Essentially, we still believe that the

rich *deserve* to be rich and the poor *deserve* to be poor." Again, there is the assumption of equal opportunity and a denial of socialized disadvantage.

Of course, there is a minority in Tucson that represents a diametrically opposed set of values. And its basic ideology is also illuminated by their discussion of growth, *and* by their comments on those who advocate growth:

> They (those who favor growth) believe that government's *only* role is to provide services--no rules, no regulations, not even guidelines. They feel no responsibility to the community. There is a belief--'It is *my* land, and I have the right to do anything I want with it regardless of what consequences it might have for others'; it is property rights gone amuk. There are still high rise buildings that don't meet fire codes, but although they've been cited, the city won't publish the names of the offenders.

Even this one quotation makes clear the underlying ideology; this respondent does not believe that the pursuit of individual interests is the way to bring about the common good; rather, the application of the principle of the free market to social affairs is judged to be ludicrous.

The logic of this group's position is that the distribution of economic benefits following from a free market principle is unjust, because it results not from the free play of individual effort but from the accidents of birth, from fated memberships in race, class, and nation. It is such vast social forces, not individual character, that are seen as determining most of who and what man is. To insist, then, that a free market system should be applied to human affairs is illogical and morally questionable in that its assumption of equality is patently absurd. As one exasperated respondent says of "Arizona conservatism":

> The only fairness they can conceive of is simple-minded equalitarianism. There's no question in my mind that most Arizonians, whether they know it or not, would be against the idea of the *graduated* income tax. They would see it as unfair--everybody should pay the same price.

For respondents of this ideological persuasion justice cannot be left to the market place; the common good is a *political* responsibility. It is not government's prerogative, it is its *duty* to control the economic sector of society.

For a brief period, roughly 1972-1976, Tucsonians of this persuasion gained political control. They were perceived as using political power, via zoning rules, utility regulations and prices, and so on, to regulate and limit urban growth. As one respondent said: "This hit business' pocketbook. And we got organized." Homebuilders, real estate, banking interests--all combined to become a political force by funding the

campaigns of selected candidates for city officers. In a blunt assessment of political reality, one respondent states:

> Now that we've won we're not any longer as organized, but if we were threatened it would be "Rally 'round the flag boys" in no time flat. And I don't think the anti-growth faction could mobilize anywhere near the same funding. And they don't seem to be organized anymore either.

Everyone is agreed, then, that the dominant ideology in the community remains the traditional Arizona one of unfettered growth; it is equated with freedom and the American way; it is "what made this country great." The forces aligned against it are perceived as being either in disarray or as becoming a threat only in the somewhat distant future: "The university influences students to think differently, and more and more of your youth are staying around...someday that will make a difference." But for the present, pro-growth forces remain in firm control.

In the end, then, Atlanta and Tucson are alike in that a growth ethos rests upon a core ideology that essentially generalizes the principles of capitalism to social relations. The cities differ only in so far as the degree of comfort with which this ideology is held: Atlantans are somewhat uneasy over the assumptions that holding such values makes necessary, they are troubled by possible illogicalities and possible immoralities. Not so the respondents of Tucson; they have no doubts, they have not yet been troubled by second thoughts.

<u>Lawn Watering and Education</u>: Tucsonians are convinced that they have demonstrated the efficacy of education as a conservation measure; they point with some pride to their "Beat the Peak" program, designed to lessen residential outside use of water between 4:00 and 8:00 PM. This entirely voluntary, entirely public relations effort has indeed effectively reduced peak water demands for the past three years.

In their judgment the accomplishment of such a significant reduction for so long a time must be interpreted as success in the changing of <u>behaviors</u> and <u>values</u> and <u>aesthetics</u>. Thus, habits have been broken (people do not water their lawns or wash their cars in the late afternoons or early evenings), values have been modified (the outdoor use of water during the prescribed hours is seen as "sinful" and violators are "reported" to authorities), and aesthetics have been altered (the ideal of midwestern green is beginning to give way to "desert-is-beautiful"). Some consequences, such as the changeover to desert landscaping, promise permanence. There is the conviction, then, that adult education, or resocialization for conservation, works.

As a result of "Beat the Peak," the city has "saved" (or, at least postponed) millions in the expansion of plant capacities that would have been necessary to meet rather than beat peak use.

Agriculture: Tucson lives in underground water. So do the farmlands surrounding it. That water comes from a shared basin. Given a finite pool, what one user takes decreases the amount available to other users. Whatever figures are quoted, and whatever might be the variations by area, it is clear to all that, by far, agriculture uses most of the water. That fact is the basis for a solution to future water needs in Tucson proposed over and over again in the interviews: there would be no water shortage, regardless of the rate of future urban growth, if the water that agriculture uses would be diverted to residential use. Whenever this idea was uttered, it was accompanied by the conviction that this is exactly what would eventually come to pass. Even farmers speak of its inevitability.

Given a state history of political dominance by rural interests, given the continued political power of agricultural interests, given the enormous agricultural investments of banking interests, why is there such agreement that agriculture's day are numbered?

The Tucsonians interviewed have a direct, marketplace answer: It can't compete economically. That is, agriculture does not benefit the state, does not produce revenues commensurate with its use of water. They argue that if the question becomes one of not-having-enough-to-go-around those interests--cities, manufacturing, mining--that produce the most money for the state will get the water; political power is seen as following the dollar.

The expectation of the future phasing out of agriculture, so certain in the eyes of so many, exerts a profound effect on the general receptivity to water conservation measures. Thus, the "Beat the Peak" program of decreasing outside watering, water-saving plumbing appliances, renovated wastewater--all of which are seen as laudatory--are also seen as trivial. As one respondent said:

> Such things are all very well, but why be concerned about what is, literally, a drop in the bucket. Why waste time and energy and money on things that will yield so little water. We're just going to take it from the farmers.

The Central Arizona Project and the Papago Indian Lawsuit: There are two issues of water supply in the Tucson area that have implications for conservation in that their outcome will determine its urgency; these are the Central Arizona Project (CAP) and the Papago Indian Lawsuit. Both are extremely complicated issues and would require considerable study to unravel their complexities to the points of confident understanding. However, here, the interest is in how these two issues are perceived by those interviewed.

Although there is considerable misunderstanding and disagreement regarding the (CAP), it is viewed as a reliable future water source for Tucson. Interviewers encountered frequent "and sometimes emotional" disagreement and misunderstanding regarding who should pay for it and who will benefit from it, what should be the size of the pipe and once it comes, will there be any water to come through it. Although each of

these questions is likely to generate much discussion and frequent emotion, it seems to be the consensus that it will be built and it will avoid future water shortages.

While all the respondents were familiar with CAP issues, the Papago Indian Lawsuit is another story. Only a few are familiar with it, with what it asks and what it might mean. Essentially, the suit refers to the agreement creating the Indian reservation which promised to forever maintain the previously unappropriated water--its quantity and quality--which the Indians enjoyed at the time or which might be needed for the purposes of the reservation.

Tucson, and other water users such as agriculture and the mining industry, take their water from the same basin as the reservation. The rate of this use has far exceeded Nature's ability to replenish and the water table has fallen dramatically. As a result, the wells of the Indians have to be deepened and their stream no longer flows.

If the suit is taken literally, restoration of the Indian's original water state would require restoring the basin's water table. The most knowledgeable respondents were agreed that this is not possible. However, in their judgment, this treaty clause could be used as leverage to gain, first, that share of available water needed for their reservation farming, and, second, a further share of water which they hope to sell to economically benefit the tribe.

Those respondents who knew most about the pending suit were agreed that the Indians, in or out of court, would win a settlement. In the end it means that the cost of water in Tucson will increase, perhaps substantially, and, thus, so might the motivation to conserve.

Questionnaire Analysis

Introduction: In order to determine the response of the general public in Tucson to water conservation, a questionnaire was mailed to a sample of 750 persons selected at random from the metropolitan Tucson telephone book. As in the Atlanta survey, this questionnaire presented eight conservation measures chosen to represent the current state of the art. But also presented were two additional water conservation measures thought to be particularly relevant to the Tucson area. These two "site-specific" measures are:

I. Farmers in the region grow only those crops which require relatively little water.

J. Landscaping of new homes uses only plants adapted to the aridity of the region.

(See Appendix B for measures A through J.)

Aside from these two additional measures, the questionnaire was identical to that sent to the general public in Atlanta. Briefly

summarized, respondents were asked, concerning each of the ten measures: how much they know about it, its effectiveness, its net benefit, how serious the need should be before it should be implemented, and their overall evaluation of the measure. Additionally, response to the issue of government enforcement of water conservation was elicited, as well as demographic information about the respondent.

Of the 750 questionnaires mailed, 82 failed to reach the intended respondent, resulting in a net mailing of 668. And of these, 177 or 26 percent were completed and returned.

And just as in Atlanta, a special interest sample was identified by the U.S. Army Corps of Engineers in Tucson on the basis of past interest expressed in water-related issues. Sixty-nine out of the 200 questionnaires sent to this special interest group were completed and returned, a response rate of 35 percent. A comparison of the response given by these two groups reveals that their level of expressed knowledge is almost identical: both groups express a great deal of familiarity with the measures presented. This similarity is undoubtedly in part a function of a biased return rate in the general public sample (e.g., higher than average education and interest in water conservation). But it also seems likely that the aridity of Tucson's climate operates to make water a salient issue for all citizens--general public as well as special interest group. Hence, only the still somewhat esoteric issue of "water-frugal" agricultural practices was more familiar to the special interest group than to the general public.

And just as in Atlanta, so too in Tucson, both the general public and special interest group expressed similar attitudes toward conservation measures. Therefore, although the conclusions reported here stem from the data provided by the general public, these conclusions are applicable to the special interest group as well.

Despite the presumed widespread interest in Tucson regarding water conservation, the unavoidable sampling pitfalls inherent in mail surveys such as this necessitate a further determination o the degree to which the general public in Tucson is, in effect, a special interest group. That is, one would want to know whether those who did not return the questionnaire would express attitudes toward water conservation similar to those found in this sample of the general public.

And as mentioned earlier, personal interviews with the general public could enrich the data contained in this report and allow substantiation of the admittedly speculative conclusions presented below. But is is this speculative quality which allows survey data to, inturn, enrich subsequent interviews by suggesting fruitful avenues of inquiry.

Rank Order of Conservation Measures: Table E-1 presents the ten conservation measures ranked according to response to the question, "Overall, how do you evaluate this conservation measure?"

This table indicates that in Tucson the most highly favored water conservation measures are sewage reuse and education, while the least favored are pricing and control of urban growth. Since the reasons for

TABLE E-1

TUCSON WATER CONSERVATION MEASURES RANK ORDERED ACCORDING TO OVERALL EVALUATION

1.	Sewage reuse
2.	Education campaigns
3T.	Building codes require water conserving fixtures
3T.	Desert landscaping
5.	Individual installation of plumbing devices
6.	Lawn-watering reduced
7.	Farmers grow water-frugal crops
8.	Government intervention during drought
9.	City controls urban growth
10.	Pricing

these ratings are not immediately apparent, perhaps an examination of the rank achieved by each of the ten measures on each of the four other questions will shed light on the contributing causes of a measure's overall evaluation (see Table E-2).

Just as in Atlanta, there is little relationship between how much an individual knows about a measure and how highly he rates that measure overall. For example, building codes and desert landscaping in overall evaluation are tied for third, but they rank ninth and first, respectively, in how much the public knows about them. Thus, a high overall ranking doesn't presume intimate knowledge of the measure.

Nor does a low overall ranking necessarily stem from ignorance of a measure. This is evidenced by the fact that lawn watering restrictions rank second in knowledge but only sixth overall. There is, however, a very slight trend for the less well known measures to be ranked slightly lower in overall evaluation. (Thus, if the five top-ranking measures in overall evaluation are summed on their rank in familiarity, the result is 22; the five lowest ranking measures' summed ranks on knowledge is 32.) This trend, admittedly mild, nevertheless suggests that if people are given the opportunity to learn more about a particular measure, they tend to evaluate it more favorably. This hypothesis, if true, would bode well for the effectiveness of educational campaigns in Tucson.

On the other hand, the direction of causality may be just the reverse. That is, a highly valued measure may "cause" people to find out more about it, either through active pursuit of information or through selective perception of the multitude of stimuli reaching us each day. And if this sketchy scenario is accurate, attempts to educate the public about less popular conservation measures may fall on deaf ears. This is an important determination which required further study. But regardless of whether overall evaluation leads to greater knowledge or vice versa, it is important to remember that the relationship between the two is mild. To understand the public's overall ranking of the measures, we must look further.

Further examination of Table E-2 yields little beyond the finding that the relationship between a measure's perceived effectiveness and net economy on the one hand, and its overall evaluation on the other, is lukewarm. For example, education is ranked eighth and sixth on these two "pragmatic" dimensions but ranks second in overall evaluation. And sewage reuse is ranked fourth in net economy but first overall. Apparently, overall evaluation of a conservation measure is the result of much more than an economic cost-benefit analysis.

But this is not to say that this type of rational process does not enter at all into the evaluation process. Certain measures, such as control of urban growth and pricing, do show a relationship between overall rank and perceived effectiveness, for example. But because these relationships are mild and/or apply only to certain measures, they serve to confuse rather than clarify the relevant conceptual issues.

In summary, this array of ranking offers a sort of "bird's-eye" view of the data and thus helps provide a sense of perspective. In certain

TABLE E-2

TUCSON WATER CONSERVATION MEASURES RANK ORDERED ON FIVE DIMENSIONS OF OPINION

Conservation Measure	Knowledge	Effectiveness	Economical	Willingness to Implement	Overall Evaluation
Sewage reuse	5	1	4	1	1
Education	4	8	6	3	2
Building Codes	9	3	3	2	3.5
Landscaping	1	2	1	4	3.5
Install Plumbing Devices	3	6.5	5	5	5
Reduce Lawn Watering	2	4	2	6	6
Water-frugal crops	10	6.5	7	8.5	7
Govt. Intervention	8	5	8	10	8
Control Urban Growth	7	9	10	8.5	9
Pricing	6	10	9	7	10

instances, it can help to define important theoretical issues and suggest implications of alternative courses of action. This wide-angle perspective runs the risk of blurring fine detail, and therefore, must be supplemented by the narrower focus which follows.

Composite Favorability to Water Conservation; Distribution and Breakdown by Age, Sex, Education, and by Attitude Toward Government Enforcement: Each individual's response to the question, "Overall, how do you evaluate this conservation measure?" for each of the ten measures was averaged, yielding a "composite favorability score." This score, because it is derived from an individual's response to a variety of conservation measures, can be thought of as representing his favorability toward water conservation in general.

As Figure E-1 shows, the response of the general public in Tucson to water conservation is overwhelmingly positive. Over 94 percent expressed favorable attitudes toward the measures presented.

This approval rate is 5 percent higher than in Atlanta. And at such extremely high levels of approval, a 5 percent increase seems substantial in that it indicates Tucson's great awareness of water-related issues and consequent receptivity to conservation.

Further evidence of this climate-induced receptivity is provided by a breakdown of the overall approval rate into its component parts; moderate approval vs. strong approval. In Tucson, 34 percent of the citizens expressed strong approval of water conservation. This proportion of enthusiastic support, 10 percent higher than that found in Atlanta, may have ramifications for actual implementation. It may indicate not only a willingness in Tucson to cooperate which conservation efforts, but suggests that measures requiring active implementation--vs. passive acceptance--might be more successful in Tucson than in areas where support is less enthusiastic.

It should be kept in mind that 60 percent of Tucson's citizens express only moderate approval of water conservation. And given Tucson's arid climate and the presumed tendency of those most interested in conserving to respond, this is a surprisingly lukewarm response. But an attempt to gain further understanding of this response by examining demographic correlates yields nothing. There is no relationship between an individual's degree of approval concerning water conservation and his age, sex, or education. Therefore, to the extent that this sample reflects Tucson's general population, it would be unnecessary for planning efforts to take these factors into consideration.

In addition to asking respondents how favorably they view the ten conservation measures, the questionnaire also asked how they would feel about government enforcement of these measures. And as Figure E-2 indicates, favorability toward government enforcement of water conservation is strongly related to how favorably one views conservation itself.

Thus, virtually everyone who strongly favors water conservation, approves of government enforcement of conservation measures. And this

FIGURE E-1

AVERAGE RESPONSE TO 10 WATER CONSERVATION MEASURES: TUCSON

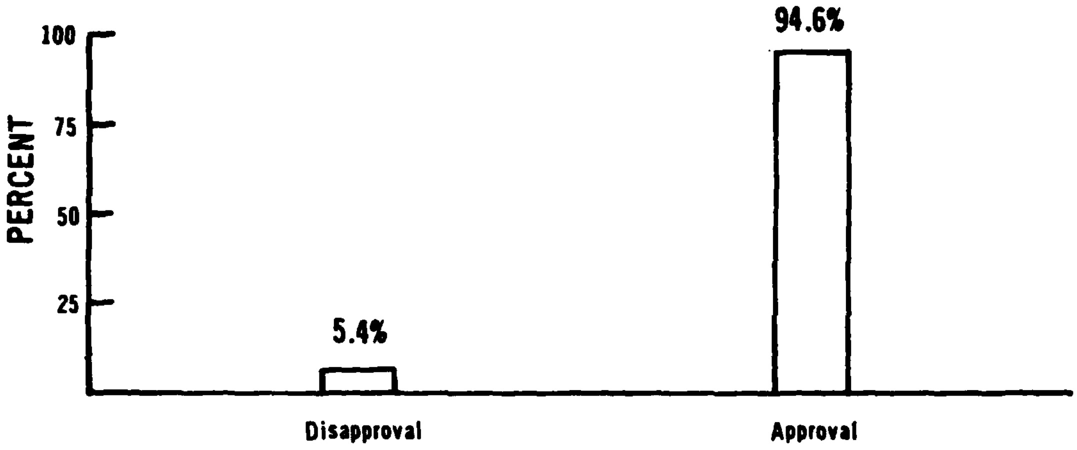
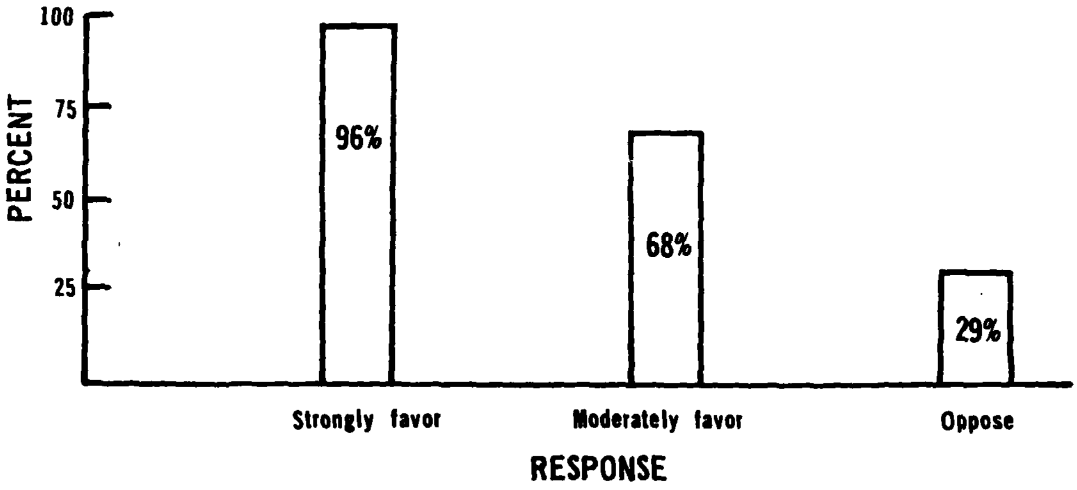


FIGURE E-2

RESPONSE TO GOVERNMENT ENFORCEMENT OF WATER CONSERVATION MEASURES AS RELATED TO ATTITUDES TOWARD THE CONCEPT OF WATER CONSERVATION: TUCSON



favorable attitude toward government enforcement is still expressed by 68 percent of the sample even when we move down a step in favorability toward conservation; that is, to those expressing only moderate approval of conservation. And although the sample as a whole is less sanguine about government enforcement of water conservation than about water conservation itself, still, 96 percent of the total sample express approval of this concept.

This figure is remarkably high when one considers the prevalent attitude toward government in the United States today which, gently put, favors a laissez faire approach. And it is even more remarkable when one adds to this general attitude the traditional antipathy in the western United States toward government intervention. Thus, the fact that in spite of these ideological obstacles, over three-fourths of the sample favor government enforcement indicates that Tucson residents not only approve of water conservation in principle but recognize the imminent need for actual implementation.

Obviously, this does not mean that Tucson residents would be equally receptive to government enforcement of each of the ten measures. But neither can it be assumed that they would most strongly approve of government enforcement of those measures which they value the most. Certain conservation measures, such as desert landscaping may be popular but, because of ideological considerations, still be considered absolutely outside of government purview (e.g., "A man's home is his castle.") Therefore, further inquiry should be conducted to determine which measures are seen by the public as appropriate for government intervention.

Analysis of Response to Pricing and Water-Frugal Crops as Water Conservation Measures, Tucson: Below is a more detailed analysis of the response to two conservation measures: pricing and the agricultural practice of planting water-frugal crops. These measures are presented here not because they are somehow "typical" conservation measures, thus allowing the particulars of analysis to be applied to other measures as well. The intended purpose is, rather, to illustrate the general process by which quantitative survey data, derived from respondents' qualitative opinions and feelings, can be translated back into qualitative information, but at a more useful level of abstraction.

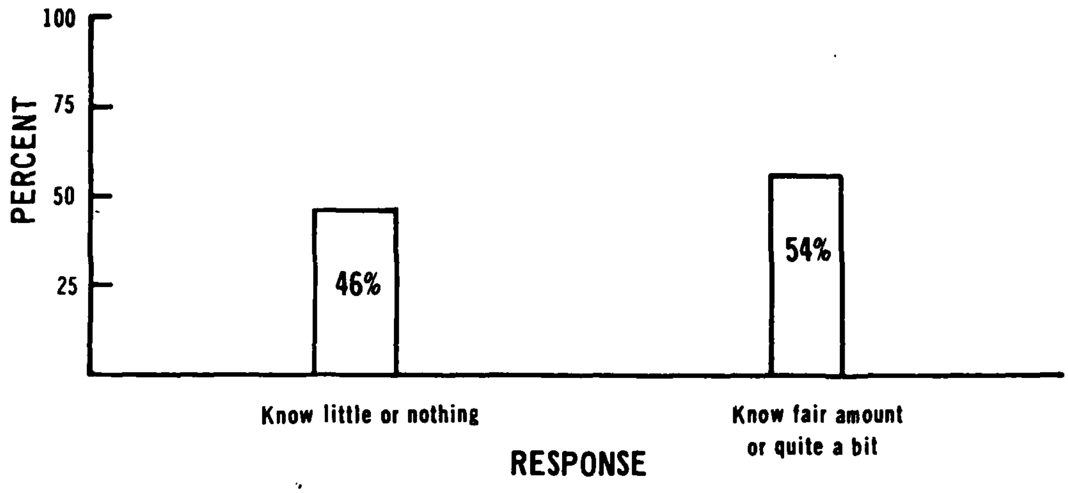
Price: As Figure E-3 shows, almost half the sample knows little or nothing about pricing as a means of water conservation. And this despite the fact that pricing is not a low-ranking measure in familiarity to the public (see Table E-2).

Surprisingly, then, citizens of Atlanta and Tucson, despite tremendous differences in climate and consequent availability of water, demonstrate a dishearteningly similar ignorance of specific conservation measures. And in particular regard to pricing in Tucson, this lack of knowledge is especially surprising given its status in recent years as somewhat of a "cause celebre."

An examination of other dimensions of opinion concerning pricing reveals a pattern apparently identical to that found in Atlanta. That

FIGURE E-3

KNOWLEDGE OF PRICE AS A WATER CONSERVATION MEASURE: TUCSON



is, despite higher than 50 percent approval rates in perceived effectiveness and net economy, 70 percent of the sample are against implementation unless the need for water is at least moderately serious (see Figures E-4, E-5, E-6).

This similarity between the two cities seems to cast doubt on the conclusion drawn earlier that Tucson's citizens do recognize the imminent need for implementation of water conservation measures. However, closer scrutiny of the data at hand suggests that this original conclusion may have been correct overall. For opinion that implementation of conservation measures should be contingent on a serious need for water says nothing about the perceived current need. In other words, it may be that Tucson citizens do recognize the current need for water as serious and, thus, the condition upon which implementation is contingent has been met and implementation could occur.

But the point being made here is not that the data definitely indicate a current recognition of need. The point is, rather, that if these data regarding implementation conditions are to be used to their potential, they should be supplemented by information about perceptions of current and anticipated need. And this requirement for further information is underscored by the fact that there are no age, sex, or educational differences in opinion regarding any question on price.

In summary then, we are presented with rather global findings regarding price. But even these general characterizations have helped identify a particular avenue of inquiry which could shed light on relationships now concealed in the data.

Agricultural Practices: "Water-Frugal" Crops

"Water-frugal" Crops: Turning now to public response to water-frugal crops we see the reemergence of two general patterns noted throughout this summary. The first of these patterns is the strikingly high proportion of uninformed response. Thus, as Figure E-7 shows, only 41 percent of this sample of the interested general public express knowledge about this measure and 59 percent know little or nothing about it. Admittedly, this is the measure about which the sample knows least (see Table E-2) and one could reasonably conclude from this that it is an esoteric issue, the knowledge of which is reserved only for those with a special interest. But this conclusion seems to beg the question. Why is it that, in an arid environment, where agriculture consumes over 80 percent of all water, the public doesn't know more about the topic of climate-appropriate crops?

From the data available, one can only speculate. the most probable reason is that the perceived need for water in Tucson has not reached the level of urgency necessary to spur the public to seek answers far outside of their daily routine. And a correlary to this explanation is that a great proportion of Tucson's residents are recent arrivals from the urban snowbelt and hence know little of the area's economy or history and even less about agriculture in general. Thus, it would be helpful to determine whether attitudes toward water conservation in general and farming practices in particular are a function of whether one is a native Tucson resident or a "transplated" one.

FIGURE E-4

PERCEIVED EFFECTIVENESS OF PRICING AS A CONSERVATION MEASURE: TUCSON

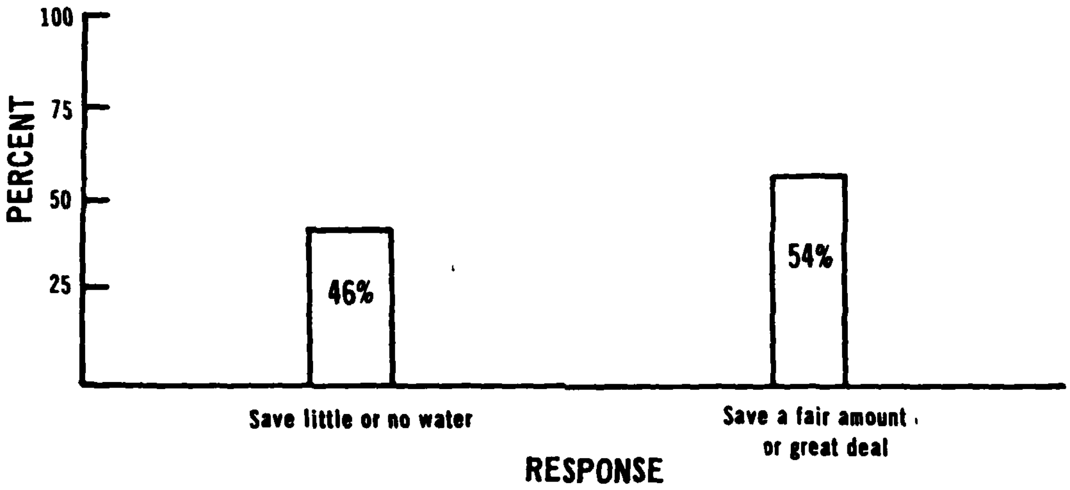


FIGURE E-5

PERCEIVED NET ECONOMIC EFFECT OF PRICING AS A WATER CONSERVATION MEASURE: TUCSON

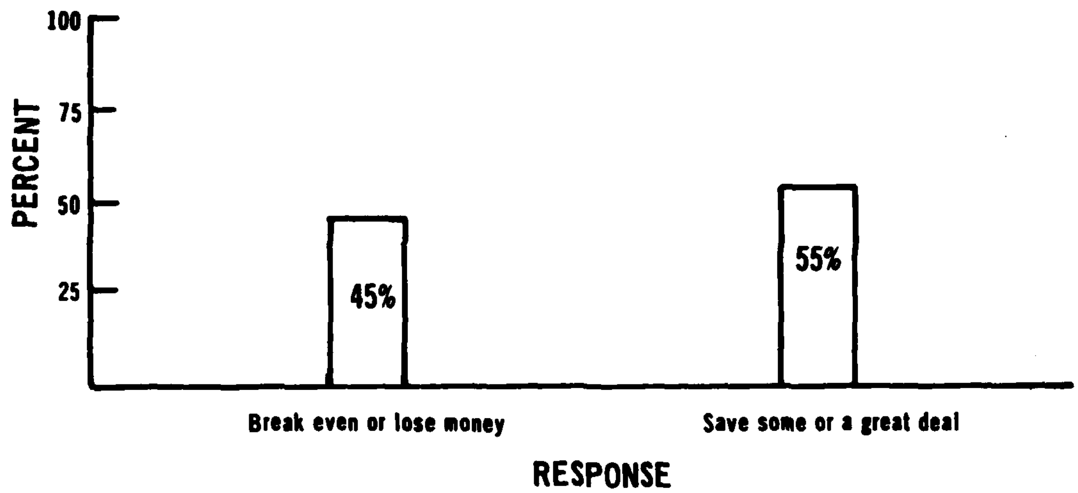


FIGURE E-6

WILLINGNESS TO IMPLEMENT PRICING AS A CONSERVATION MEASURE AS TO HOW SERIOUS THE NEED MUST BE: TUCSON

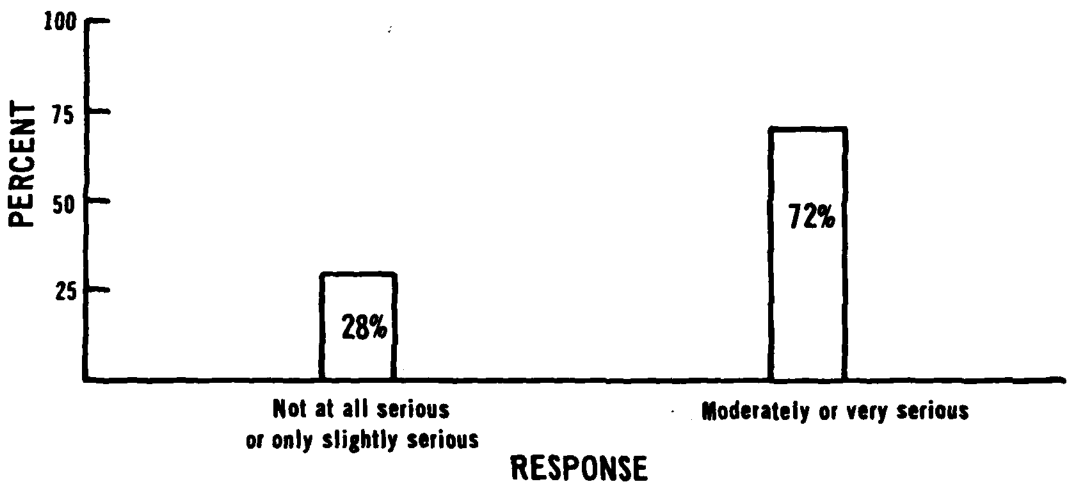
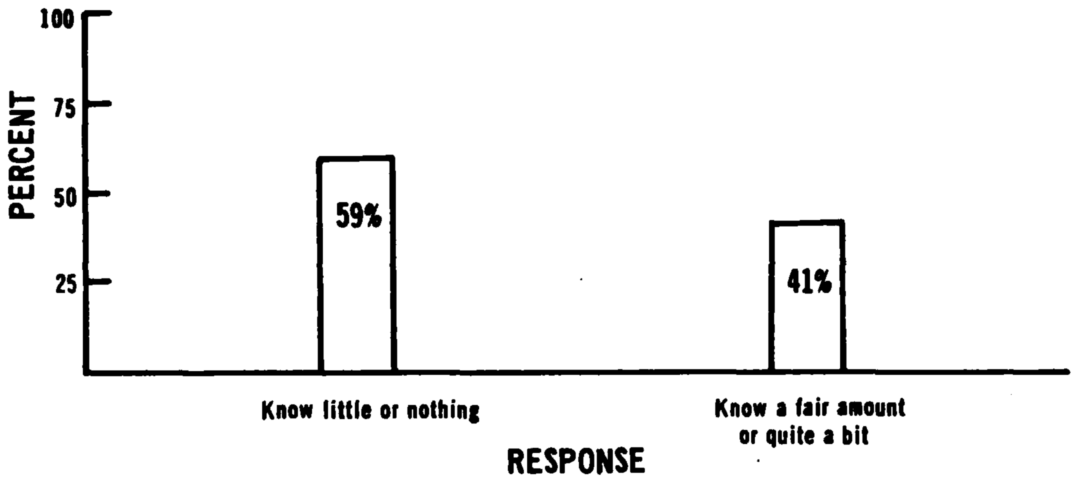


FIGURE E-7

KNOWLEDGE OF 'WATER - FRUGAL' CROPS
AS A WATER CONSERVATION MEASURE: TUCSON



A second general theme which appears in this data is the very loose relationship between amount of knowledge about a measure and how favorably it is viewed. As Figure E-8 shows, 60 percent of the sample favor "water-frugal" crops overall. Hence, even making the doubtful assumption that all of the 40 percent who express familiarity with the measure also favor it overall, this means that at least 20 percent of the sample rate the measure favorably despite admittedly inadequate knowledge. Of course the questionnaire format forces the respondent to make these decisions regardless of familiarity. But, nevertheless, it is interesting that, under such conditions, a substantial portion of the sample does not require "hard facts" to come out in favor of a measure.

Whether such a response tendency toward approval of a measure in the abstract would carry over into approval of actual implementation is doubtful. But nevertheless, the implications of this tendency for water conservation should be explored. And because there are no age, sex, or education differences in the responses to "water-frugal" crops, it is crucial that deductively derived dimensions such as length of residence in Tucson and response tendency be examined in further research. Through identification of relationships such as these, progressively more precise theoretical refinements can be achieved, thus allowing more accurate prediction of actual outcomes.

<u>Response to Government Enforcement of Water Conservation Measures, Tucson</u>: As indicated in Figure E-9, the Tucson sample favors by a three to one margin government enforcement of certain water conservation measures. And given the ideological obstacles to pro-government response mentioned earlier, the fact that this ratio is substantially higher than Atlanta's indicates how strongly the residents of Tucson feel about water conservation.

As has been the case throughout this analysis, there are no age, sex, or education differences in opinion regarding government enforcement of water conservation. This might constitute further evidence of the salience of water conservation issues in Tucson: the differences in opinion regarding the role of government often thought to be associated with age and education have perhaps been overridden by a more pressing concern about water.

Because of the global nature of these findings, it is important to discover what kinds of demographic and attitudinal differences are associated with different opinions on the subject. Is it simply the case that if one feels strongly enough about the need for conservation one is willing to approve of government enforcement? Or are there people who have equally favorable opinions about the need for conservation but who oppose government enforcement on other grounds? If the first alternative is true, then effective education campaigns on water conservation would reap the additional benefit of gaining support for government involvement.

It appears likely that the underlying causes of attitudes toward government enforcement are more complex. Evidence that this is the case lies in the greater expressed approval of the conservation measures themselves than of government enforcement (95 percent and 76 percent of

FIGURE E-8

OVERALL EVALUATION OF 'WATER - FRUGAL' CROPS AS A WATER CONSERVATION MEASURE: TUCSON

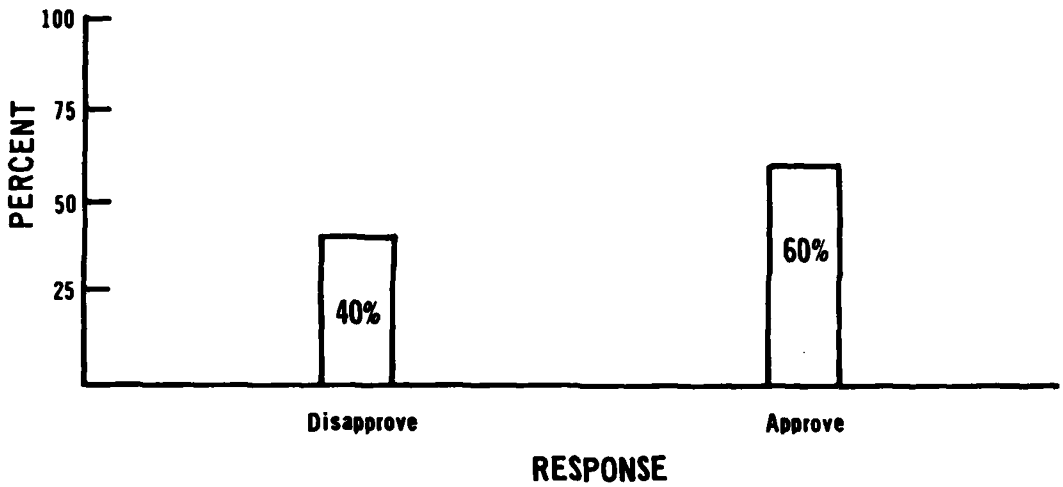
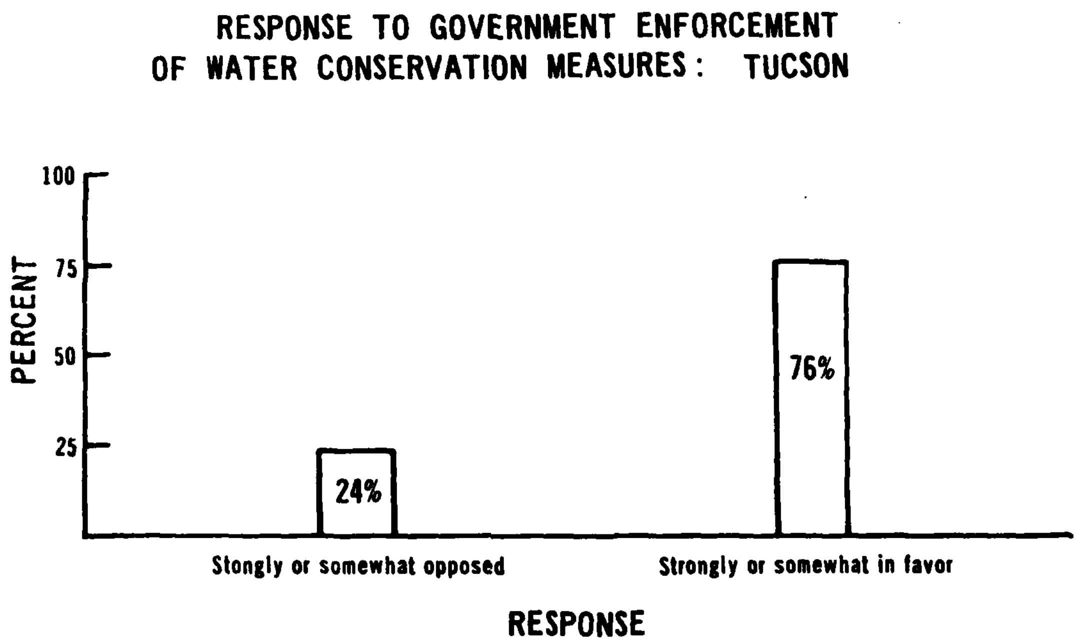


FIGURE E-9


RESPONSE TO GOVERNMENT ENFORCEMENT
OF WATER CONSERVATION MEASURES: TUCSON
PERCENT
100
75
50
25
24%
76%
Stongly or somewhat opposed
Strongly or somewhat in favor
RESPONSE

the sample, respectively). Thus, just as in Atlanta, a large number of respondents who favor conservation object to government enforcement. And exactly what underlies this apparently ideologically based stance is uncertain but worthy of further inquiry.

Thus, as has been the case throughout this report, the data have generated many questions and few, if any, definitive answers. In so doing, the survey has managed, first, to provide a broad overview of the issues entailed in determining social acceptability; second, to highlight the areas of particular complexity for further study; and, third, to provide guidelines for that future study.

Implication of Results

As with Atlanta, the study on social acceptability in Tucson, although equally brief and limited, produced clear outlines of major ideological themes as well as considerably detailed assessments of a number of specific conservation measures.

Once again the task becomes one of speculating on the possible relationships between our data-based sense of community values and a selection of conservation measures in an effort to evaluate their social acceptability. The question this inquiry asks is: If such and such measure (whatever it may be) is proposed, what chance does it have of being accepted? As a preface to our examination, perhaps earlier cautions should be repeated: the goal of a study of social acceptability is to improve judgments made on the probability of community acceptance or rejection. To do this involves the processes of speculation and conjecture; that is, the making of inferences from inconclusive evidence. To be honest, the aim of a study of social acceptability is to provide such inconclusive evidence on the logic that it is better than no evidence at all.

Pricing: To appreciate the current use of increasing block rates as a conservation measure in Tucson, some history is necessary. Prior to 1975, Tucson had a long-established price structure in which variance was based primarily upon the costs of delivery. There were three rates: a "low" charge within the city limits, a "moderate" charge in the area on the periphery of the city, and a "high" charge in areas extending beyond. Secondarily, there was a minor, indeed, insignificant rate increase based on amount of water used.

Then, in 1976, major and highly visible changes in water pricing policies were inaugurated--a highly complex increasing block rate structure was interwoven with a complicated system of delivery charges. Quite naturally, these water policies did not please those whose waterbills were substantially increased.

More important, these water policies, most particularly the dramatic increases in delivery charges, were perceived by certain community powers, notably homebuilders and land developers, as part of the incumbent city government's attempts to limit Tucson's growth. They organized, and through their leadership and money, promoted and channeled public outcry, eventuating in a successful recall election. The newly

elected officials proceeded to do more than retreat to the previous rate structure, they did away with all rate differentials whether based on amount of water used or on costs of delivery. Shortly thereafter, however, increasing block rates were not only restored, they were greatly strengthened, but to this day there is no recognition in price of the substantial difference in costs of delivery between city and distant, expanding suburbs. Thus, the concept of using pricing to conserve water by reducing demand per household was supported and advanced, but the principle of using pricing to conserve water by limiting the number of households was rejected.

This plotline is not the full story. There are several issues that deserve a closer look. First, the response of the construction interests: the respondents were agreed that their political mobilization was a response to what they saw as an economic threat. A no growth or limited growth or controlled growth policy would have seriously hurt their business. However, there were moral as well as economc concerns involved in their efforts to remove the incumbents from office. For in their eyes, the powers of government were being wrongfully used to restrict the exercise of two freedoms basic to American life--locally, they had intervened in the workings of the market and, nationally, they had attempted to restrict movement:

> Nobody has the right to tell somebody that you can't move to Tucson, and in effect, that's what you're doing when you make the price of water prohibitive. And who's to say that you can't build homes for them. They'll come anyway. What do you want, a ring of trailer camps around the city?

Such sentiments, frequently voiced, reveal the deeply felt ideological offense that was a part of their entrance into the field of politics.

In addition to being perceived as violating the right of mobility and the freedom of the marketplace, rates based on delivery costs were also seen as at odds with another important value--Tucson's dominant definition of equality.

The concept of equality most favored by the Tucson respondents is a literal one: Everyone is to be treated the same way, rich or poor, inner city or football suburb, those of luxurious or spartan life style. In terms of the pricing of water, this translates into a simple maxim: Everyone should be charged the same cost for the same amount of water, *and that means* the same price per gallon regardless of where one uses it. Because variation in price based on delivery costs is perceived as clearly correlated with status differences in neighborhoods, it raises the suspicion that those who strive to raise their standards of living are being punished for their achievement; such rates constitute a discriminatory tax on the "rich." It was such arguments incorporating such values that pressed the public to change its elected officials.

Rate differences based on amount of water used manage to avoid the charge of being discriminatory--for no matter who uses the water, and

regardless of where it is used, greater use means a higher rate. No one is favored and no one injured; it is "fair." The use of pricing as a conservation measure has succeeded in Tucson because it is tied to the value of equality.

To say that pricing is successful as a conservation measure in Tucson is not to say that it is popular. Indeed, the questionnaire data show the opposite--it is ranked last in overall evaluation of the ten conservation measures the public reviewed. And indeed, over two-thirds (69 percent) of the sample feel that it should be implemented only when the water supply is seen as constituting a fairly serious problem. But it is these same figures that clue the reason for its acceptance, because Tucsonians are concerned over their water supply. However begrudging, it appears that the Tucson public will accept a conservation measure, even one that hurts them economically, if it is perceived as fair.

It should be remembered that prior to the political furor resulting in the recall election, Tucson had had a variable rate structure based on delivery costs that had encountered no substantial opposition. But the political processes provoked by its extension suddenly spotlighted the policy and made its ideological base visible. The public's values were then "energized" and their power of decision exercised.

Plumbing Appliances: Paradoxically, in lush, green Atlanta, with rain, river and lake, a plumbing code has recently been enacted mandating the use of low-flow appliances in new construction, while in desert Tucson, with a dramatically falling groundwater level, with a highly visible need for water, with well-publicized water conservation programs, such a code has not yet been considered. An attempt to understand why is at the same time a way of estimating the measure's social acceptability.

When the idea of the measure was presented to them, the response of most respondents was puzzlement at the lack of such a code. Challenged, the respondents offered possible reasons:

> 'It may be that the City Council want to stay away from favoring particular manufacturers.'
>
> 'It would be yet another regulation, and that would mean yet another building inspector.'

Both answers identify an ideological theme that characterizes Tucson and which acts unconsciously to screen out from consideration a measure that might offend it. Thus, both responses assume the ideological stance that government should avoid interfering with business, that it shouldn't intervene or participate in market affairs where economic forces alone should operate.

Such then may be the values and attitudes that, probably unknowingly, have kept plumbing codes from consideration as a conservation measure, and, of course, it is these very same values and attitudes that would have to be overcome, or rather satisfied, if plumbing codes were to be made socially feasible.

As the analysis of plumbing codes in Atlanta revealed, it is likely that the measure could be defined and presented in such manner as to make it sufficiently congruent with Tucson values. The logic that the proposal must follow is this: such a code does not interfere with the free play of economic forces in the market, it does not affect the cost of home building or the price of home buying as the low-flow appliance costs the same as the standard appliance, nor does it disadvantage the retailer of plumbing appliances as implementation of such a code could be dated to permit liquidation of standard inventories.

Interestingly, each of these considerations was offered by the respondents themselves in their discussions of the measure's possibilities. And in the end, there was general agreement that essentially nothing "stood in the way" of such a code being adopted.

Yet there was no enthusiasm. While there was agreement that it was reasonable, harmless, that it wouldn't cost anybody anything, that indeed, it might even be a selling point to those home buyers who were conservation-minded, so was their agreement that it was essentially idle, that the amount of water such a measure would save was insignificant, hardly worth the effort. And <u>this</u> conviction is not so easily overcome.

An attitude which dismisses conservation efforts as trivial is a function of attitudes toward water <u>supply</u>. There is the determined, albeit uneasy, belief in Tucson that problems of urban water <u>will</u> be solved through augmentation of supply. To look in the other direction, that is, toward solution through decreasing demand, is rarely even considered--for one reason, because it would have serious implications for what is seen as the city's unlimited potential for growth, a belief that functions as a point of honor for Tucson. All eyes, then, are fastened on supply possibilities--the pipelines of the CAP, retired farming land, deeper wells.

In the context of these convictions, the prospects of a plumbing code enjoying energetic support from community powers are dim. On the other hand, at the worst, it would be viewed as innocuous, and at best as "good for PR" for both city officials and the home construction industries. The social acceptability then of a plumbing code change is neither poor nor good but fair in that it is a function of the absence of opposition rather than the presence of support.

As measured by the questionnaire, the public's stance on plumbing codes mirrors, in great part, the position of the Tucson interviewees just described. Thus, they too are generally ignorant of the use of such codes as conservation measure (it ranks ninth out of ten regarding knowledge about); yet, at the same time, they are quite positive about the idea when it is presented to them (it ranks third out of ten in overall evaluation). It would appear then that public response to its proposal would echo the unenthusiastic endorsement of the city's powers--a stolid acceptance.

APPENDIX F

H.B.N. 546

STATE OF GEORGIA

HOUSE BILL NUMBER 546

H.B.N. 546
By: Representatives Carlisle of the 71st, Nichols of the 27th, Horton of the 43rd, Glaton of the 66th, Mostiler of the 71st, McDonald of the 12th, Knight of the 67th and others.

A BILL TO BE ENTITLED
AN ACT

To provide that no building shall be constructed within this State after a certain date which employs water closets or shower heads which exceed a certain rate in the use of water; to provide that such requirements shall be applicable to construction involving the repair or renovation of or addition to buildings; to provide for certain ordinances of counties and municipalities and for certain exemptions in connection therewith; to provide for other matters relative to the foregoing; to provide for a penalty; to repeal conflicting laws; and for other purposes.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF GEORGIA:

Section 1. (a) After January 1, 1978, no building of any type shall be constructed within this State which:

(1) Employs a tank-type water closet that uses more than an average of 3.5 gallons of water per flush; or

(2) Employs a shower head that allows a flow of more than an average of 3.5 gallons of water per minute.

(b) The requirements of subsection (a) of this Section shall apply to any construction after January 1, 1978, which involves the repair or renovation of or addition to any existing building when such repair or renovation of or addition to such existing building includes the replacement of water closets or showers or both. As used herein, the word "construction" means the alteration of an existing building in connection with its repair or renovation or in connection with making an addition to an existing building, but such word does not mean and shall not include the mere replacement of a malfunctioning, unserviceable, or obsolete shower, shower head or water closet in an existing building.

(c) Counties and municipalities are hereby authorized and directed to provide by ordinance for an exemption to the requirements of subsection (b) of this Section, relative to the repair or renovation of an existing building, under the following conditions:

(1) When the repair or renovation of the existing building does not include the replacement of the plumbing or sewage system servicing water closets or showers with such existing building, and

(2) When such plumbing or sewage system within such existing building, because of its capacity, design or installation, would not function properly if the water closets or shower heads required by this Act were installed.

(d) The ordinances adopted by counties and municipalities pursuant to subsection (c) of this Section shall provide procedures and requirements to apply for the exemption authorized by said subsection.

Section 2. The Environment Protection Division of the State Department of Natural Resources shall annually publish a list of waterclosets and shower heads which comply with the requirements of Section 1 of this Act. The first such list shall be published by July 1, 1977.

Section 3. Any person who installs any water closet or shower head, after January 1, 1978, in violation of Section 1 of this Act shall be guilty of a misdemeanor and upon conviction thereof shall be punished as for a misdemeanor.

Section 4. All laws and parts of laws in conflict with this Act are hereby repealed.

Source: Atlanta Regional Commission (October, 1977)

APPENDIX G

AN ORDINANCE PROVIDING FOR MINIMUM STANDARDS AND REGULATION TO PROVIDE FOR WATER CONSERVATION IN PLUMBING SYSTEMS

AN ORDINANCE PROVIDING FOR MINIMUM STANDARDS
AND REGULATION TO PROVIDE FOR WATER CONSERVATION
IN PLUMBING SYSTEMS

BE IT ORDAINED by the Board of Commissioners of DeKalb County, Georgia, that it is hereby ordained by the authority of same, that Chapter 15, entitled "Plumbing," of Part II of the Code of the DeKalb County, Georgia, is hereby amended by adding a new Section 15-107A as follows:

Section 15-107A Water Conservation

(a) In all new construction only fixtures and trim not exceeding the following flow rates of water usage shall be installed.

Water Closets, tank type--3.5 gal. per flush
Water Closets, one piece combination--(no requirements for one year).
Water Closets, flush valve type--(no requirements for one year).
Urinals, tank type--3.0 gal. per flush
Urinals, flush valve type--3.0 gal. per flush
Shower heads--3.5 gpm
Lavatory, sink faucets--4.0 gpm up to.

(b) Car wash installation.

All new car wash installations shall be equipped with an approved water recycling system.

(c) All flow rates shall be tested at 60 PSI.

(d) Exceptions.

(1) Water closets, tank type designed for handicapped.
(2) Water closets, tank type designed for juveniles.
(3) Industrial flood shower heads (emergency use).

Effective date July 1, 1976

Source: Atlanta Regional Commission (October, 1977)

APPENDIX H

WATER CONSERVATION STRATEGIES

TABLE H-1

WATER COSTS FOR VARIOUS WATER HARVESTING TREATMENTS[1]

Treatment Type	Runoff Efficiency (PERCENT)	Estimated Life of Treatment (YEARS)	Incremental Annual Cost (DOLLAR/ACRE-FEET)[2]	Quality Considerations
Land clearing	20-30	10	107-170	Sitting problem
Soil smoothing	25-35	10	133-192	Sitting problem
Silicone water repellent	50-80	8	90-152	--
Sodium Treatment	40	10	130	--
Paraffin wax	80-90	8	193-224	--
Concrete	80	20	956	--
Gravel covered sheeting	70-90	20	176-235	--
Asphalt-fiberglass chip	90+	15	189	Possible asphaltic cut back component
Asphalt-rubber chip	90+	15	270	Possible asphalic cut back component
Sheet metal	90+	20	739	--
Mertor coated pastic	90+	40	318	--

[1] Does not include storage or transportation costs.
[2] Based on life of treatment at 6 percent interest.

Source: Dr. C. B. Cluff, Gary Frasier, and Staff estimates.
Pima Association of Governments, Large Array of Water Conservation Strategies for Pima County, Arizona (1978)

TABLE H-2

CONSERVATION STRATEGIES AGRICULTURAL IRRIGATION

Conservation Strategy	Savings (ACRE-FEET PER YEAR)	Implementation	Cost (DOLLAR/ACRE-FOOT PER YEAR)	Technical Feasibility	Funding	Obstacles	208 Management Coordination
Land leveling	28,000 to 39,000 if cropped acres remain constant	Tax incentive state regulations	37-51	Known	Federal State Local	Profit Incentive	Nonpoint source management agency Planning agency
Efficient delivery				Known			
Soil moisture, crop monitoring and irrigation management service				Known			
Crop selection	112,000 if cropped acres remain constant	State regulations	None	Known	N/A	Interference with free enterprise system, profit	
Cropped acreage retirement	44,600 in 1980 to 204,000 in 2000	Local policy decision to continue to purchase farm land	28-35	Known	Local	Cost of farm land; land use values; other environmental considerations	Planning agency

Source: Pima Association of Governments, Water Resources Summary (1978).

TABLE H-3

FLOW REDUCTION MEASURES

Category	Control Measure	Reduction in Wasteflow[1] (PERCENT)	Incremental Unit Cost[2] (DOLLARS)	Incremental Unit Benefits[3]	Major Advantages	Disadvantages
Reduction of storm-water inflow	Reduces ponding over manhole covers	Varies with precipitation	50-100 per manhole	None	Reduces hydraulic load to STP	Poor ventilation in sewers
	Prohibit new drainage connections	Varies with amount of new construction	1.80[4]	None	Reduces hydraulic load to STP	May cause drainage problems

[1] Estimated percent reduction in household wastewater flows resulting from implementation of the control measure.
[2] The estimated additional cost per unit associated with implementing the control measure.
[3] Computed as the estimated monthly savings per household in water and energy costs that would occur if the control measure were to be implemented.
[4] Prorated administrative cost per household.

Source: Pima Association of Governments, Large Array of Water Conservation Strategies for Pima County, Arizona (1978).

TABLE H-4

CONSERVATION STRATEGIES MUNICIPAL

Category	Central Measure	Reduction in Flow[1] (PERCENT)	Incremental Unit Cost[2] (DOLLARS)	Incremental Unit Benefits (DOLLARS PER MONTH)	Major Advantages	Major Disadvantages
Interior Water use	Water-saving toilet	9	10/toilet	0.90	Easy to purchase	Expensive to replace existing toilet
	Dual-flush toilet	21	Negligible	2.10	Reduces flush volume	Not readily available
	Vacuum toilet	27	100/toilet	2.70	Major reduction	Expensive in water use
	Reduced-flush toilet	12	0 to 14	1.20	Easy to install	Inconsistent effectiveness
	Flow-limiting showerheads	12	5	4.00	Easy to install	No obvious disadvantage
	Flow-limiting faucets (kitchen/bath)	2	5	0.55	Minimizes water use	Requires skilled installation
	Faucet aerators	2	2	0.32	Easy to install	No obvious disadvantage
	Pressure-reducing valves	5	25	1.70	Reduces excessive household pressure	Should not be used in older homes
	Insulation of hot water pipes	4	1.00 per lineal foot	1.40	Energy savings	Primarily for new homes
	Water-saving clothes washer	6	25	2.00	Energy savings	Expensive to replace existing machine

TABLE H-4 (Continued)

CONSERVATION STRATEGIES MUNICIPAL

Category	Central Measure	Reduction in Flow[1] (PERCENT)	Incremental Unit Cost[2] (DOLLARS)	Incremental Unit Benefits (DOLLARS PER MONTH)	Major Advantages	Major Disadvantages
Interior Water Use (cont.)	Water-saving dishwasher	4	Varies	1.20	Energy savings	Expensive to replace existing machine
	Premixed water systems	8	100	2.70	Energy savings	Expensive
	Repair of faucet and toilet leaks	Varies	Varies	Up to 5	Energy savings	Expensive if plumber required
	Washwater recycle systems	30	640 for prototype	3.00	Major reduction in wastewater flow	System needs refinement
	Restrictions on home garbage disposals	21 reduction in suspended solids	3.00/mo	.40	Reduces pollutant load to STP	Increases solid waste
	Prohibiting use of phosphate detergents	50 reduction in phosphorus	None	None	Reduces required chemicals for STP	No obvious disadvantage
	Restricting biotoxic products	15-20 reduction in biotoxic wastes	1.20 (4)	None	Improves conditions for aquatic life	Adequate substitutes not always available
Exterior Water Use	Landscape design	23	Old-10/yd^2 New-Negligible	2.80	Water and energy savings	Expensive to replace existing
	Plant selection	7	Old-10/yd^2 New-Negligible	.70	Water and energy savings	Expensive to replace existing

TABLE H-4 (Continued)

CONSERVATION STRATEGIES MUNICIPAL

Category	Central Measure	Estimated Reduction in Flow[1] (PERCENT)	Incremental Unit Cost[2] (DOLLARS)	Incremental Unit Benefits (DOLLARS PER MONTH)	Major Advantages	Major Disadvantages
Exterior Water Use (cont.)	Pool covers	30-65	7.00/mo	33.00	Water and energy savings	Short life expectancy of covers
Incentives	Pricing systems	10-50 increase in water rates	Varies	2.60[5]	Incentive for water conservation	Consumer objection
	Industrial sewer meters	3	4,000/tap typical	Varies with industry	Encourages waste-water reuse	High cost of meters
	Marketing	Varies	Negligible	Varies	Voluntary program marketing techniques	Primarily for new facilities
	Public education for water conservation	Varies with method chosen	1.14/mo		Encourages voluntary water conservation	Requires co-ordinated efforts

[1] Estimated percent reduction in household flows resulting from implementation of the control measures.
[2] The estimated additional cost per unit associated with implementing the control measures.
[3] The actual waste flow reduction would vary depending on the industry.
[4] Computed as the estimated monthly savings per household in water energy costs that would occur if the control measure were to be implemented.
[5] Does not reflect a rate increase which would probably have to occur in order to encourage water conservation.
Source: Pima Association of Governments, Water Resources Summary (1978).

TABLE H-5

NATURAL WATER SUPPLY CONSERVATION STRATEGIES

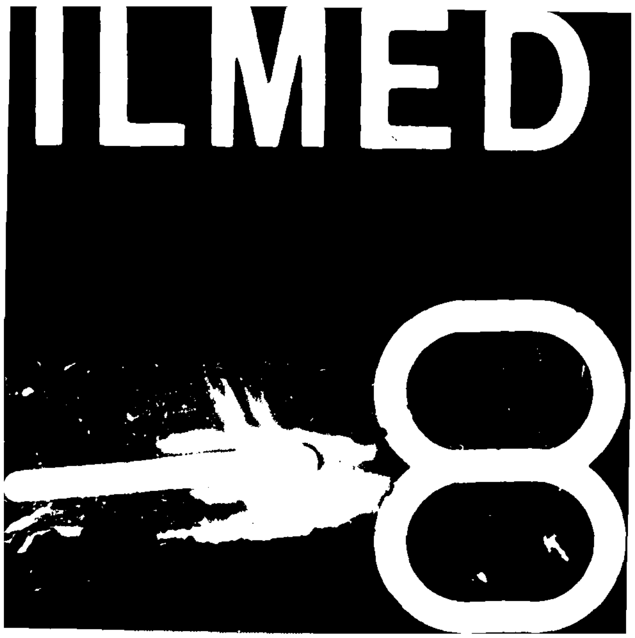
Loss Type	Amount Lost (ACRE-FEET)	Conservation Strategy	Savings (ACRE-FEET)	Implementation	Cost (DOLLARS PER ACRE-FEET)
Underflow out of the county	16,000	Dewatering system	Undefined 5,000-10,000	Local policy guidance Federal, State, County, Local government cooperation and coordination	185-972
Surface flow out of the county	20,000	Detention reservoirs for storage and/or ground recharge	Up to 20,000	Local policy guidance Federal and State cooperation in a river orientated project	Depends on scope and method
Other losses evapotranspiration	2,800,000	Various methods of watershed management and water harvesting	Depends on scale of project and method of harvesting	Local policy guidance Federal, State, and County cooperation on land availability	Depends on scope, method and location

TABLE H-6

NATURAL WATER CONSERVATION STRATEGIES

Loss Type	Technical Feasibility	Funding	Obstacles	208 Management Coordination
Underflow out of the county	Known	Local	Loss in relatively undefined and unconfined Contribution to subsidence Competition with private landowners for water	None
Surface flow out of the county	Known, except for portions of the recharge system	Federal State Local	Land required for structural solution Arizona water law--prior appropriation The structural solutions themselves Continued operation and maintenance costs Potential of private retrieval of publicly developed water	Nonpoint source management agency Planning agency
Other losses evapotranspiration	Vegetation management known; soil treatment under investigation; storage methods under investigation; transportation known; reduction of storage evaporation under investigation	Local	Need additional technological information in some areas Concept not completely proven Land use conflict Environmental costs: -effect on wildlife -effect on aesthetics	Nonpoint source management agency Planning agency

Source: Pima Association of Governments, Large Array of Water Conservation Strategies for Pima County, Arizona (1978).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